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OIL AND GAS DEVELOPMENTS IN PENNSYLVANIA IN 1990 WITH TEN-YEAR REVIEW AND FORECAST



William S. Lytle

John A. Harper
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TOPOGRAPHIC AND GEOLOGIC SURVEY
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DEDICATION

This volume is dedicated to William Stuckley Lytle (1915–1991) in grateful acknowledgement of his 34 years of service to the public. Bill began working full-time at the Pennsylvania Geological Survey in 1940 and, except for a four-year tour of duty in World War II, remained at the Survey until his retirement as Chief of the Oil and Gas Geology Division in 1977. Widely regarded as the Survey's expert on oil and gas resources, Bill prepared 23 annual issues of Oil and Gas Developments in Pennsylvania, dating from 1954 through 1976. The authors of this year's report have benefited from his knowledge, and many of his ideas are reflected herein.

Progress Report 204

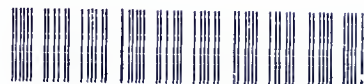
OIL AND GAS DEVELOPMENTS IN PENNSYLVANIA IN 1990 WITH TEN-YEAR REVIEW AND FORECAST

by John A. Harper and Cheryl L. Cozart
Pennsylvania Geological Survey

PENNSYLVANIA GEOLOGICAL SURVEY
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1992

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OIL AND GAS DEVELOPMENTS IN PENNSYLVANIA IN 1990 WITH TEN-YEAR REVIEW AND FORECAST

by

John A. Harper and Cheryl L. Cozart

ABSTRACT

Oil production in Pennsylvania totaled 2,601,035 barrels in 1990, just 947 fewer barrels than in 1989. Oil reserves decreased 6.3 percent, from 41,563,000 barrels in 1989 to 38,962,000 barrels in 1990. The leading counties for production of oil remained the same as in 1989: Warren, Elk, McKean, and Venango. In 1990, oil production in the Bradford field accounted for only 17 percent of the state total.

Gas production decreased 7.4 percent, from 191,774 million cubic feet in 1989 to 177,609 million cubic feet in 1990. Gas reserves continued to decline, from 1,983,587 million cubic feet in 1989 to 1,935,253 million cubic feet in 1990. Stored recoverable gas had a significant increase of 18.5 percent, from 503,974 million cubic feet in 1989 to 597,286 million cubic feet in 1990.

The price for Penn Grade crude oil and oil products continued on an upward swing to \$25.59 per barrel by the end of 1990, averaging \$22.94 per barrel for the year. Most new-gas prices were subject to Natural Gas Policy Act (NGPA) price ceilings. The well-head price of 1,000 cubic feet of natural gas ranged from a low of \$0.29 under old contracts to \$6.37 for "tight" gas (NGPA Section 107, High-Cost Gas). The average price for gas was about \$2.35.

The total number of wells reported drilled in 1990 was 1,173, a 23 percent decrease from 1989; the total footage drilled declined by 32 percent to 3,800,117 feet. Less than half of the total number of wells reported in 1990 were actually completed in 1990. The total number of oil wells reported increased 15 percent to 377. The most active county for oil well drilling was again Warren, accounting for 62 percent of all oil wells drilled in the state. The number of gas wells reported in 1990 decreased drastically

to 634, a 40 percent drop from 1989. The most active counties for gas well drilling in 1990 were Indiana, Venango, Armstrong, Warren, Jefferson, Westmoreland, Clinton, and Crawford, accounting for 80 percent of all gas wells drilled in the state. There were 45 combination oil and gas wells reported in 1990, down only 4 wells from 1989. Practically all (40) of these wells were drilled in Mercer County.

Development drilling in 1990 decreased 27 percent to 1,041 wells. Exploratory drilling also decreased 28 percent, from 68 wells reported in 1989 to 49 wells reported in 1990. The success rate for development drilling remained high at 98 percent, and the success rate for exploratory drilling remained about the same at 63 percent.

Seismic exploratory activity increased slightly in 1990 to 5 crew-months, up from 4.5 crew-months in 1989. Seismic crews operated in six counties in Pennsylvania during the year.

Project activity within the Oil and Gas Geology Division of the Pennsylvania Bureau of Topographic and Geologic Survey in 1990 included continued updating of the oil and gas base map series and continued work on projects dealing with the geochemistry of petroleum source rocks and the feasibility of producing coal-bed methane.

A 10-year review and forecast is included in this text. The oil and gas industry experienced a great deal of turmoil during the 1980's, starting with a "boom" in the early part of the decade and ending with a "bust" that began in the middle part of the decade. Significant exploratory activity opened numerous new fields and pools, and there was substantial expansion of the Upper Devonian, Ridgeley, and Medina producing areas of the Commonwealth. The coming decade does not look promising for the oil industry because the domestic agenda calls for stricter controls on

drilling and production, and reduced production will require an increase in the amount of imported oil. The gas industry should fare better because the agenda calls for cleaner burning fuels. Exploration of several major areas and horizons may provide new reserves for future exploitation.

INTRODUCTION

This annual report of oil and gas drilling and production in Pennsylvania is based for the most part on drillers' well records and location plats filed with the Pennsylvania Department of Environmental Resources, Bureau of Oil and Gas Management. The statistics of oil and gas drilling are compiled only from the records received by the department during the calendar year. This includes records of wells drilled prior to, but reported in, 1990; it does not include wells for which records were submitted after December 31, 1990.

Nineteen ninety could have been a better year than it was for the oil and gas industry in Pennsylvania. The Persian Gulf crisis helped to send crude oil prices soaring during the latter half of the year. Penn Grade crude oil prices, which peaked at \$34.34 in October, have not been so high since early 1982. Of course, there was the usual hyperbole associated with the effects of a possible war on future crude oil prices. One story, from Reuters News Service in September, reported that a former Saudi Arabian oil minister predicted oil prices as high as \$60/bbl (barrel) if war actually broke out. However, neither the realistic higher prices nor the speculation of outrageous future prices could stimulate new drilling and production in Pennsylvania in 1990. Although reported oil well drilling increased by 15 percent over 1989, a large number of the well records received and included in 1990 statistics were from the early to mid-1980's, and some records dated back as far as 1969! Even more discouraging is the fact that, according to statistics from the Bureau of Oil and Gas Management, there were more than 2.5 times as many old oil wells plugged as there were new oil wells reported drilled. Oil production decreased slightly in 1990; the production of 2.6 million bbl was nowhere near the post-OPEC (Organization of Petroleum Exporting Countries) peak of 4.8 million bbl recorded in 1984 and 1985.

In the natural gas industry, the relatively warm winter in early 1990 resulted in a continuing surplus

of marketable supplies. Thus, although the industry produced 177.6 Bcf (billion cubic feet) of gas, it experienced a 7.4 percent reduction in production from 1989. In addition, reported drilling for natural gas declined by 40 percent. The only bright news for the gas industry came from the Federal Energy Regulatory Commission, whose officials proposed new regulations that would allow tax credits for certain categories of gas. These regulations, if passed, would take effect in 1991.

ACKNOWLEDGEMENTS

Grateful acknowledgement is extended to the following industry and government organizations, without whose help this report would have been impossible: the American Gas Association; the Pennsylvania Department of Environmental Resources, Bureau of Oil and Gas Management, and Bureau of Forestry, Division of Minerals; and the U.S. Department of Energy.

Mary Ann Gross, Equitrans, Inc., supplied statewide data on natural gas production and reserves. Victor Samuelson, a McKean County historian, provided vital data on the Bradford oil field.

Special thanks go to all of the operators, companies, and personnel of Pennsylvania's oil and gas industry who provided data on producing formations, intervals, drilling costs, oil and gas prices, and other miscellaneous information throughout the year.

The following staff members of the Pennsylvania Bureau of Topographic and Geologic Survey, Oil and Gas Geology Division, are acknowledged: Christopher D. Laughrey, who assisted with the deep-well summary tables; and Lajos J. Balogh, who drafted the figures.

PRODUCTION AND RESERVES

CRUDE OIL PRODUCTION

Pennsylvania's crude oil industry produced 2,601,035 bbl of Penn Grade crude oil in 1990, only 947 fewer barrels than the 1989 production total of 2,601,982 bbl. As in the past, most of this production was from Upper Devonian and Lower Silurian reservoirs, but there was probably some subsidiary production from Pennsylvanian, Mississippian, Middle Devonian, and Upper Silurian reservoirs. Lower Silurian Medina Group sandstones in Erie, Craw-

ford, and Mercer Counties produced 90,162 bbl of crude oil, 12.6 percent less than the previous year. See Figure 1 for a summary of these statistics.

Figure 2 illustrates the amount of oil produced, and it marks the first year that the number of producing oil wells by county are not officially reported. This is because most of the oil is gathered

from common tanks without knowledge of the number of wells. It is estimated, however, that the number of producing wells total 21,800. The leading counties for oil production were Warren, Elk, McKean, and Venango, in that order. These four counties were responsible for 82 percent of the total amount of oil produced in Pennsylvania.

Figure 1. *Crude oil production in Pennsylvania, 1990.*

<i>Penn Grade oil</i> ¹	<i>1990</i>	<i>1989</i>	<i>Percent change</i>	<i>Cumulative to 12/31/90</i>
Shallow oil ²	2,511	2,499	+ 0.5	1,335,913
Deep oil ²	90	103	- 12.6	2,055
TOTAL OIL	2,601	2,602	- .04	1,337,968

¹In thousands of barrels.

²See text for explanation.

Figure 2. *Crude oil production in Pennsylvania in 1990 and 1989, by county.*¹

<i>County</i>	<i>Crude oil production (barrels)</i>	
	<i>1990</i>	<i>1989</i>
Allegheny	65,723	61,382
Armstrong	9,361	10,696
Beaver	9,357	10,551
Bradford	168	0
Butler	58,741	57,416
Clarion	22,380	25,327
Clearfield	694	1,104
Crawford	70,337	84,054
Elk	625,403	638,720
Erie	7,219	9,791
Fayette	193	0
Forest	96,231	98,273
Greene	25,117	26,000
Indiana	6,643	5,669
Jefferson	4,822	4,667
McKean	439,048	353,487
Mercer	12,605	8,696
Potter	10,288	11,716
Venango	265,543	287,409
Warren	797,298	827,916
Washington	56,481	58,989
Westmoreland	17,383	20,119
TOTAL	2,601,035	2,601,982

¹Because most oil is gathered from common tanks, the number of producing wells can no longer be reported.

DEVELOPED CRUDE OIL RESERVES

Developed crude oil reserves in Pennsylvania totaled 38,962,000 bbl at the end of 1990. This represents a 6.3 percent decrease from the 1989 total of 41,563,000 bbl. The areas of the Commonwealth containing the highest reserves included the fields of McKean and Elk Counties, particularly the Bradford and Kane oil fields. All reserves probably should be estimated downward, however, because economic recoverability has suffered greatly from the impact of poor markets and increased regulation. Figure 3 shows statistics of crude oil reserves by shallow and deep reservoirs.

Figure 3. *Crude oil reserves in Pennsylvania, 1990.*

<i>Reserves</i> ¹	<i>1990</i>	<i>1989</i>	<i>Percent change</i>
Shallow oil ²	38,265	³ 40,776	- 6.2
Deep oil ²	697	³ 787	- 11.4
TOTAL OIL	38,962	41,563	- 6.3

¹In thousands of barrels.

²See text for explanation.

³Corrected figure.

ENHANCED OIL RECOVERY

Pennsylvania's oil industry reported 68 new fluid-injection wells, all of which were in Elk County. This compares to only 19 fluid-injection wells completed in 1989.

The Bradford field in McKean County is the first field in which large-scale, intentional waterflooding was attempted. Flooding probably began by accident sometime in the late 1800's, and intentional flooding began soon after. It was not until the early 1900's, however, that noticeable production enhancement became apparent. Since that time, most

of the Bradford field has been under waterflood. Figure 4 shows the changes in oil production in Pennsylvania since Drake's well was drilled in 1859 and the changes in oil production in the Bradford field. It should be noted that in 1990 the Bradford field produced only 17 percent of the total state production, whereas 10 years ago the Bradford field production represented 33 percent of the state total.

NATURAL GAS PRODUCTION

Pennsylvania's natural gas production decreased in 1990 by 7.4 percent, from the 1989 total of 191,774 Mmcf (million cubic feet) to 177,609 Mmcf. The number of producing gas wells increased 1 percent to an estimated 30,400. Figure 5 shows 1990 gas production statistics for Pennsylvania. Included is a general breakdown of gas production by shallow and deep reservoirs.

NATURAL GAS RESERVES

Proven recoverable reserves of natural gas in Pennsylvania decreased 2.4 percent to 1,935,253 Mmcf in 1990. In Figure 6, 1990 natural gas reserve figures for Pennsylvania are compared with those of 1989, and Figure 7 graphically illustrates the differences among production, consumption, and reserves of natural gas since 1946.

NATURAL GAS STORAGE AREAS

Because Pennsylvania has traditionally consumed more natural gas than it has been able to produce, the natural gas industry stores gas in large quantities in the summer months to at least partially ensure an adequate supply during the winter. Storage reservoirs are typically old, depleted gas-producing reservoirs, or bodies of rock whose geological and engineering characteristics would have made them

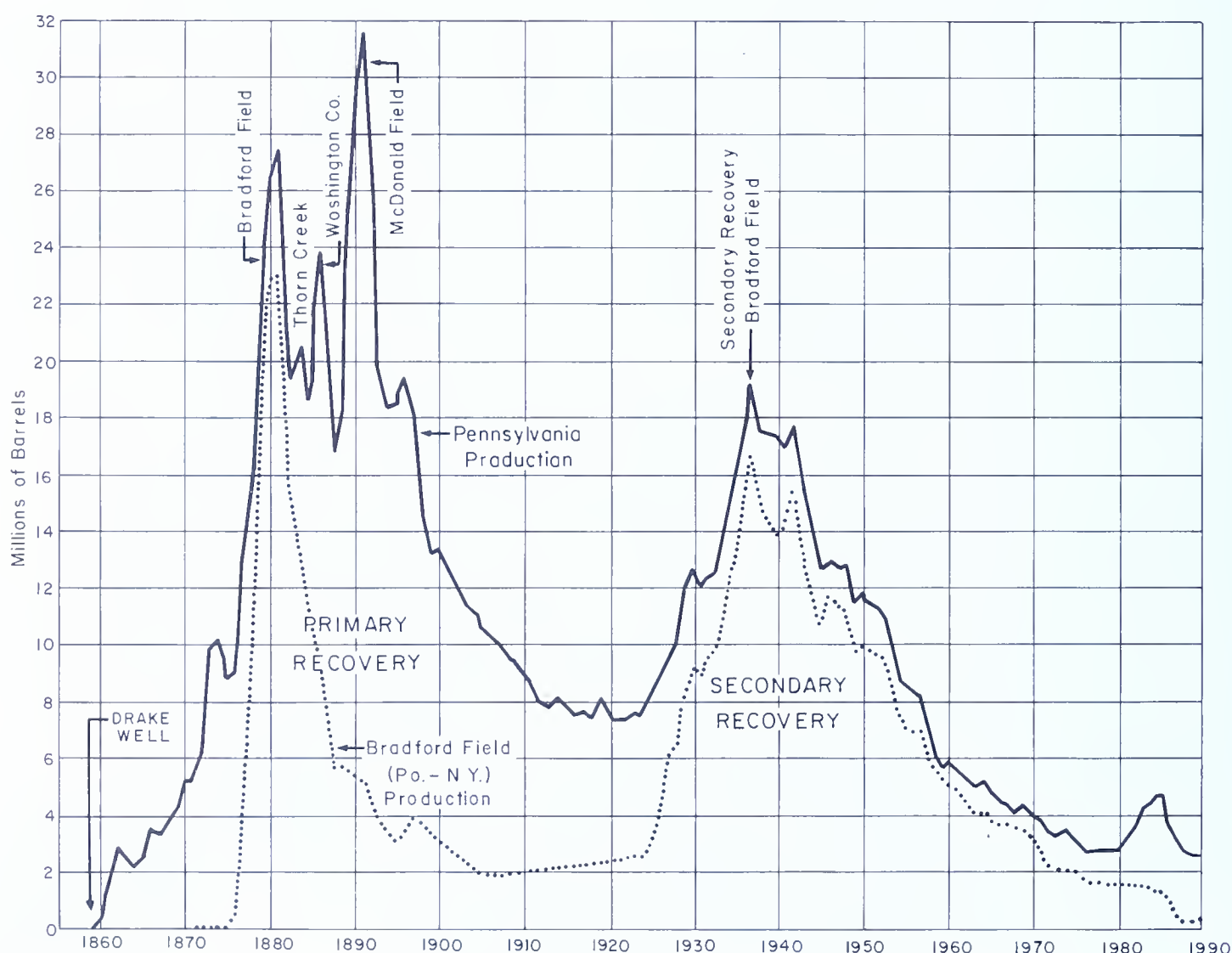


Figure 4. Annual production of crude oil in Pennsylvania, 1859-1990.

Figure 5. Natural gas production in Pennsylvania, 1990.

	¹ 1990	¹ 1989	Percent change	Cumulative to 12/31/90 ¹
Shallow gas ²	137,960	145,251	- 5.0	—
Deep gas ³	39,649	46,523	- 14.8	—
TOTAL GAS	177,609	191,774	- 7.4	10,929,860

¹In millions of cubic feet.²Shallow gas: from Late Devonian or younger rocks, generally less than 4,000 feet deep.³Deep gas: from Middle Devonian or older rocks, generally more than 4,000 feet deep.**Figure 6. Natural gas reserves in Pennsylvania, 1990.**

	¹ 1990	¹ 1989	Percent change
Total gas	1,935,253	² 1,983,587	- 2.4
Stored recoverable gas	597,286	503,974	+ 18.5

¹In millions of cubic feet.²Corrected figure.

ideal reservoirs had natural gas been emplaced in them. In Pennsylvania, all of the major gas-producing horizons have been used at one time or another as storage reservoirs, but the most common reservoirs are Upper Devonian Bradford and Venango Group sandstones and fractured reservoirs in the Ridgeley Sandstone. Figure 8 shows the locations and names of all active gas storage areas in Pennsylvania in 1990. There were 11 wells reported in 1990 for gas storage. One storage well is in the Venango Group, and the other 10 gas storage wells are in the Ridgeley Sandstone. Recoverable gas in storage increased to 597,286 Mmcf in 1990 as compared with 503,974 Mmcf in 1989 (Figure 6). This represents an 18.5 percent increase over last year.

OIL AND GAS PRICES

The price for crude oil in Pennsylvania continued on an upswing during 1990 to a high of \$34.34/bbl. At the end of the year, the price of crude oil was \$25.59. The average price for the year was \$22.94/bbl, representing the highest average since 1985. Changes in crude oil pricing in 1990 are shown in Figure 9.

Natural gas prices have been subject to controls under the Natural Gas Policy Act (NGPA) since

1978. The pricing structure of the NGPA raised natural gas prices gradually since then in order to provide operators with more realistic product prices. The lowest prices paid by utilities in Pennsylvania were for old gas, subject to old contracts, produced from pre-NGPA wells. Prices as low as \$0.29/Mcf (thousand cubic feet) are common for gas bought under old contracts in some of the older producing areas of the Commonwealth. Some NGPA pricing categories have been deregulated since January 1, 1986. The highest price allowed for NGPA-regulated gas was \$7.324/Mcf for Section 107 (High-Cost Gas, in this case the price allowed for gas from "tight formations" such as the Lower Silurian Medina Group and certain Upper Devonian sandstones). The highest price paid for gas in 1990 was \$6.37/Mcf, and the average price for gas was approximately \$2.35/Mcf. Figure 10 shows NGPA price ceilings for natural gas during 1990.

1990 DRILLING AND COMPLETIONS

TOTAL COMPLETIONS

Drilling activity as reported by Pennsylvania's oil and gas industry declined even further in 1990 to 1,173 reported wells. This is a 23 percent decrease over activity reported in 1989 and represents the smallest number of new wells reported since 1973. The total includes 1,166 new wells and 7 old wells drilled deeper. Of these 1,173 wells reported in 1990, only 46 percent were actually drilled in 1990. Pennsylvania's oil and gas industry submitted records on wells drilled and completed as far back as 1969. Figure 11 shows the breakdown of wells reported in 1990 but completed in prior years.

The total footage drilled in all reported wells decreased by 32 percent, from 5,620,710 feet in 1989 to 3,800,117 feet in 1990. The average total depth in all wells drilled decreased to 3,240 feet. This is directly attributed to the fact that the number of oil wells reported increased and the number of gas wells reported decreased. The six most active counties for drilling in 1990 were Warren, Elk, Indiana, Venango, Armstrong, and Mercer, accounting for 73 percent of all wells reported in the Commonwealth during the year (see Figure 12).

OIL COMPLETIONS

Oil well drilling increased 14.5 percent in 1990 to 377 wells reported during the year (Figure 13). Ninety-five percent of the reported oil wells were

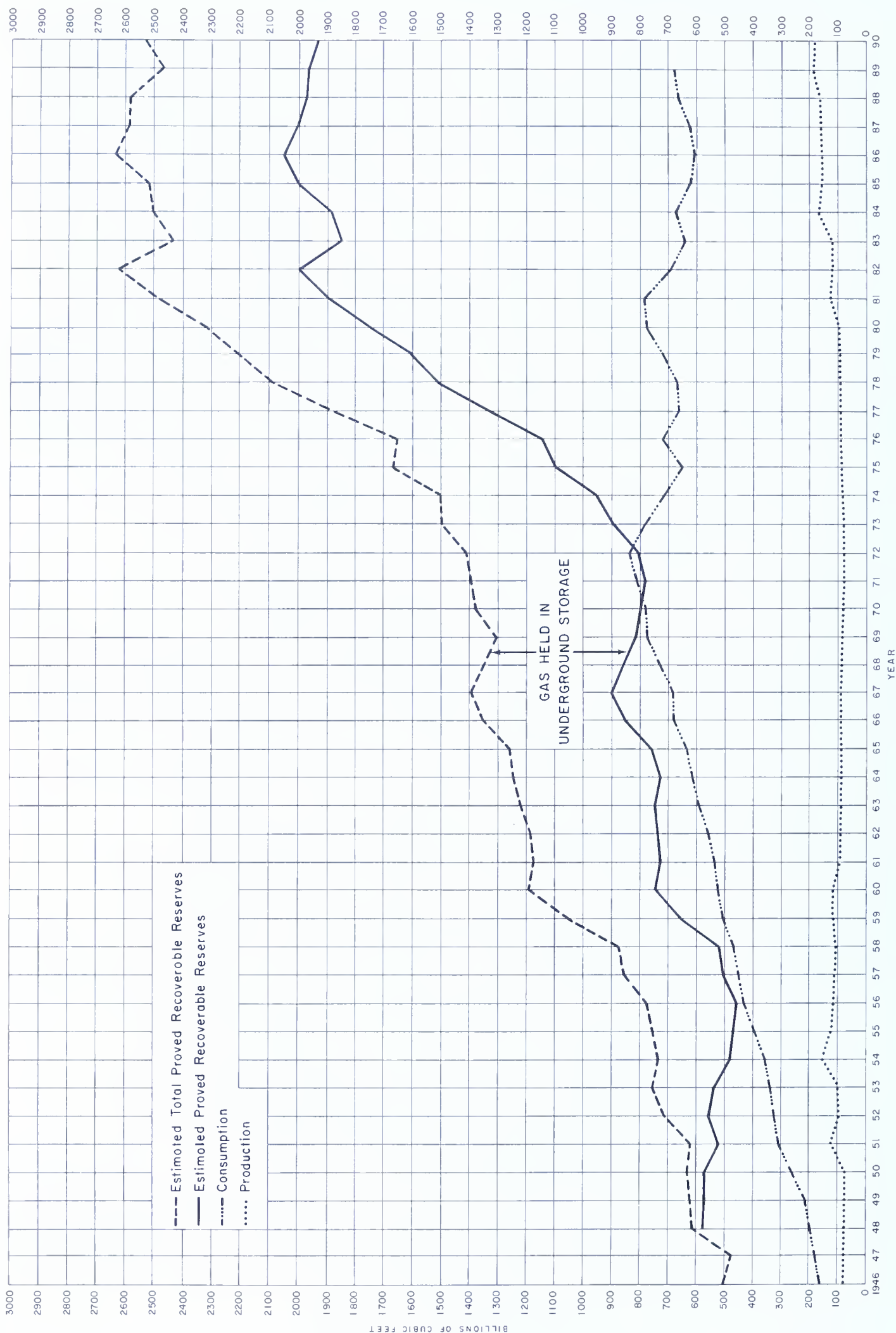


Figure 7. Production, consumption, and reserves of natural gas in Pennsylvania, 1946-90 (consumption data are reported one year in arrears).

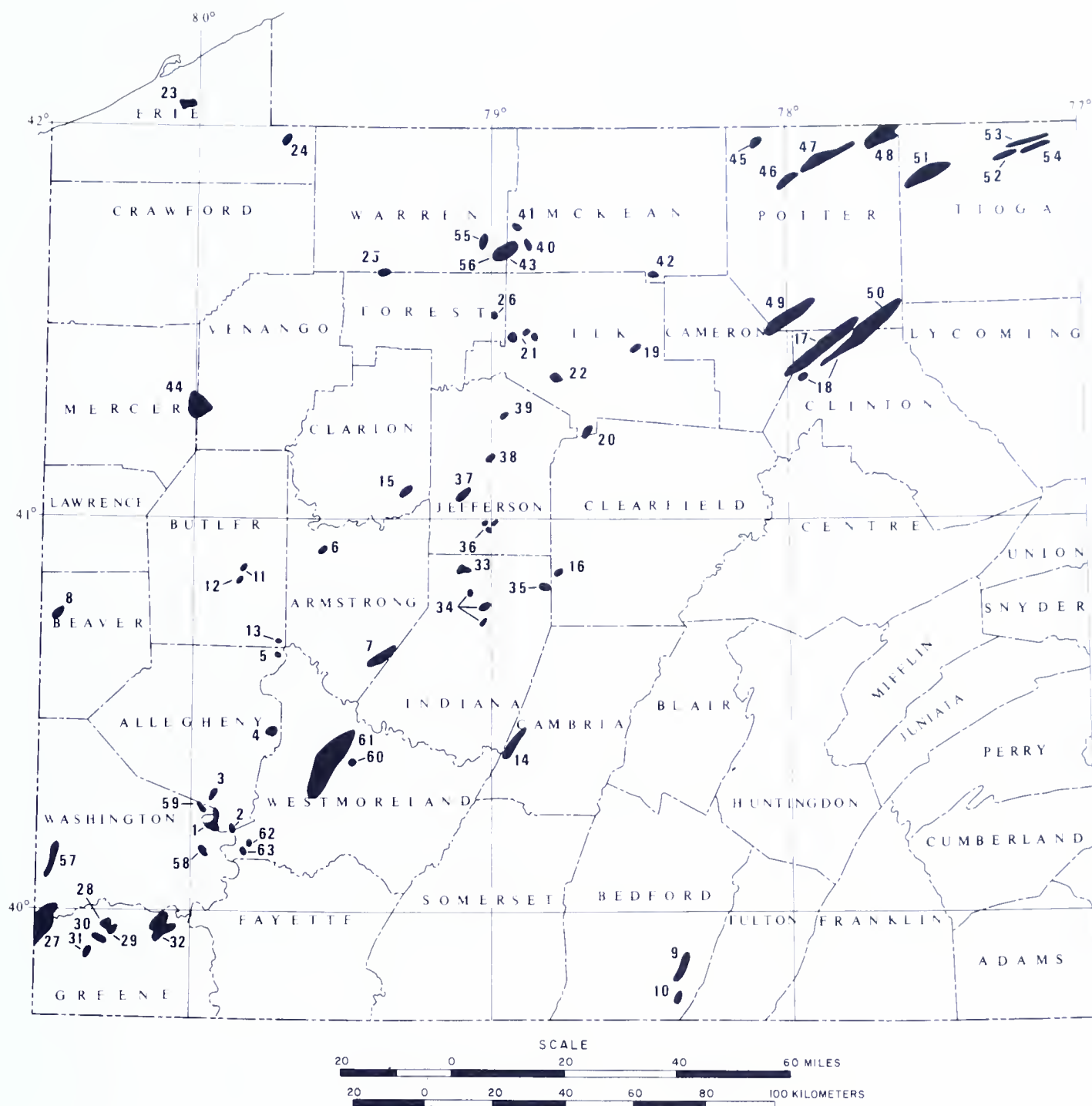


Figure 8. Active natural gas storage areas of Pennsylvania.

NAMES OF ACTIVE GAS STORAGE AREAS IN PENNSYLVANIA

ALLEGHENY COUNTY	BEAVER COUNTY	CAMBRIA COUNTY	ELK COUNTY
1. Bunola	8. Black Hawk	14. Rager Mountain	19. St. Marys
2. Gamble-Hayden		CLARION COUNTY	20. Boone Mountain
3. Tepe	BEDFORD COUNTY	15. Truittsburg	21. Owls Nest
4. Murrys ville (Dice)	9. Artemas A	CLEARFIELD COUNTY	22. Belmouth
5. Smith-Parke	10. Artemas B	16. Gourley-Miller	
	BUTLER COUNTY	CLINTON COUNTY	ERIE COUNTY
ARMSTRONG COUNTY	11. Vardy	17. Leidy	23. Summit
6. Fair and Helm	12. Portman	18. Tamarack	24. Corry
7. South Bend	13. Hughes		

NAMES OF ACTIVE GAS STORAGE AREAS IN PENNSYLVANIA (Continued)

FOREST COUNTY	JEFFERSON COUNTY	POTTER COUNTY	WASHINGTON COUNTY
25. Queen	36. Sprankle	(Continued)	57. Donegal
26. Duhring	37. Galbraith	47. Ellisburg	58. Colvin
	38. Markle	48. Harrison	59. Finleyville
GREENE COUNTY	39. Munderf	49. Wharton	WESTMORELAND COUNTY
27. Majorsville-Heard	McKEAN COUNTY	50. Greenlick	60. Seanor
28. Swarts West	40. Keelor	TIOGA COUNTY	61. Oakford
29. Swarts	41. Swede Hill	51. Sabinsville	62. Webster
30. Hunters Cave	42. Wellendorf	52. Palmer	63. Patton
31. Holbrook	43. East Branch "B"	53. Tioga	
32. Pratt	MERCER COUNTY	54. Meeker	
INDIANA COUNTY	44. Henderson	WARREN COUNTY	
33. Alabran	POTTER COUNTY	55. Deerlick	
34. Kinter	45. Sharon	56. East Branch "A"	
35. Clark	46. Hebron		

Figure 9. Crude oil prices in Pennsylvania, 1990.

Month	Price per barrel
January	\$20.87
February	21.00
March	20.28
April	18.31
May	18.03
June	17.18
July	16.76
August	23.23
September	29.40
October	34.34
November	30.29
December	25.59

from three counties: Warren, Elk, and Venango. These three counties reported 358 wells. Total reported footage drilled was 535,905 feet, a 12.6 percent increase over that of a year ago. The average total depth for all oil wells remained about the same at 1,421 feet.

GAS COMPLETIONS

The number of natural gas wells reported in 1990 dropped drastically to 634, including 6 old wells drilled deeper. This represents a 40 percent decrease over the 1989 figure of 1,055 wells. Accordingly, total footage drilled in all gas wells declined 42 percent to 2,663,317 feet. The average depth for all gas wells remained about the same at 4,201 feet. The

most active counties for gas well drilling in 1990 were Indiana, Venango, Armstrong, Warren, Jefferson, Westmoreland, Clinton, and Crawford, accounting for 80 percent of all gas wells drilled in the state. Surprisingly, Erie County did not make this active-county list for the first time in the last 10 years. In 1980, 161 gas wells were reported for Erie County, whereas in 1990, only 15 gas wells were reported. Gas well completions reported in 1990 are summarized in Figure 14.

COMBINATION OIL AND GAS
WELL COMPLETIONS

(Not Reported Separately as Oil or Gas)

The Pennsylvania Geological Survey classifies a combination oil and gas well as any well that produces both oil and at least 50 Mcfgpd (thousand cubic feet of gas per day). Most oil wells drilled in Pennsylvania produce a little gas, and many produce enough gas to be sold to utilities or pipeline companies. However, if a well produces less than 50 Mcfgpd, regardless of whether or not the gas is sold, it is considered an oil well.

Pennsylvania's oil and gas operators reported 45 combination wells in 1990, an 8.1 percent decrease from the 49 wells reported in 1989; however, total footage increased by 22 percent to 241,630 feet. The average depth increased significantly to 5,370 feet due to the fact that the bulk of the reported oil and gas combination wells (40) were Medina wells in Mercer County. These data are summarized in Figure 15.

Figure 10. Natural gas price ceilings under federal Natural Gas Policy Act in 1990.

NGPA Section	Category of gas	Maximum lawful price for deliveries made in:											
		Jan. 1990	Feb. 1990	Mar. 1990	Apr. 1990	May 1990	June 1990	July 1990	Aug. 1990	Sept. 1990	Oct. 1990	Nov. 1990	Dec. 1990
		cost per million British thermal units (dollars)											
102	New, Natural Gas Certain OCS Gas	Deregulated January 1, 1985											
103(a)	New, Onshore Production Wells ¹	Deregulated January 1, 1985											
103(b)(1)	New, Onshore Production Wells ²	3.515	3.526	3.537	3.548	3.565	3.582	3.599	3.612	3.626	3.640	3.651	3.662
107(c)	Gas Produced from Tight Formations ³	7.030	7.052	7.074	7.096	7.130	7.164	7.198	7.224	7.252	7.280	7.302	7.324
108	Stripper Gas	5.947	5.984	6.021	6.058	6.106	6.154	6.203	6.246	6.289	6.332	6.371	6.410
109	Not Otherwise Covered	2.909	2.918	2.927	2.936	2.950	2.964	2.978	2.989	3.000	3.011	3.020	3.029

¹Wells deeper than 5,000 feet.²Prices only apply to Interstate. All previous 103 categories are now deregulated.³Prices only apply to tight-sand formations. All other 107 categories are now deregulated.

Figure 11. Number of well records received in 1990 by completion date.

Completion date	No. of wells
1969	1
1973	2
1976	3
1977	3
1978	2
1979	1
1980	15
1981	10
1982	53
1983	34
1984	29
1985	49
1986	9
1987	15
1988	33
1989	371
1990	543
TOTAL	1,173

DRY COMPLETIONS

Only 34 dry holes were reported in Pennsylvania in 1990. These wells represent a 47 percent decrease in the number of dry holes from 1989, when 64 dry holes were reported. Consequently, the overall success rate increased to 97 percent. The total footage for dry holes in Pennsylvania in 1990 was 118,376 feet, a 63 percent decrease from 1989. The average total depth for dry holes was 3,482 feet (Figure 16).

MISCELLANEOUS WELLS

Miscellaneous wells include all wells that cannot specifically be considered oil- and gas-producing wells or dry holes. They include service wells and junked and abandoned wells. Service wells comprise several types: stratigraphic core tests, drilled to collect subsurface information such as formation thickness or the effects of well completion on various rock types; water-supply wells for waterflood projects; fluid-injection wells for secondary and tertiary recovery of oil; liquid-waste disposal wells; and gas storage wells. Increases and decreases within this category do not accurately reflect oil and gas drilling trends because, for example, an oil field opera-

Figure 12. Reported new well completions and old wells drilled deeper in Pennsylvania, 1990.

REPORTED NEW WELL COMPLETIONS		
County	No. of wells	Average total depth (feet)
Allegheny	9	3,807
Armstrong	74	3,444
Butler	2	1,378
Cambria	2	6,386
Centre	21	4,758
Clarion	11	2,192
Clearfield	22	3,968
Clinton	42	5,038
Crawford	35	4,781
Elk	167	2,486
Erie	24	2,658
Fayette	9	4,384
Forest	14	1,528
Greene	1	3,700
Indiana	125	3,694
Jefferson	46	3,302
Lawrence	3	785
McKean	10	2,224
Mercer	68	5,461
Potter	8	6,067
Somerset	6	8,857
Tioga	5	913
Venango	113	3,922
Warren	306	2,092
Westmoreland	43	3,645
TOTAL	1,166	3,254

REPORTED OLD WELLS DRILLED DEEPER		
County	No. of wells	Average amount deepened (feet)
Erie	1	1,207
Indiana	2	1,424
Jefferson	2	669
Tioga	1	162
Westmoreland	1	38
TOTAL	7	799

tor may drill all needed water-supply wells and fluid-injection wells several years after the oil-producing wells have been completed.

There were 83 miscellaneous wells reported in Pennsylvania in 1990, almost triple the number reported in 1989. This increase is attributed to the increase in reported Elk County water-intake wells (68). In addition to the 68 miscellaneous wells re-

Figure 13. Reported new oil well completions in Pennsylvania, 1990.

County	No. of wells	Average initial production (bopd) ¹	Average total depth (feet)
Allegheny	1	4.00	2,890
Butler	2	1.00	1,378
Elk	86	4.37	2,469
Erie	1	5.00	2,798
Forest	7	.29	1,021
Lawrence	1	.20	655
McKean	4	0	1,863
Mercer	2	7.63	844
Potter	1	0	1,270
Venango	40	9.63	905
Warren	232	8.87	1,124
TOTAL	377	7.55	1,421

¹bopd, barrels of oil per day.

ported as water-intake wells for secondary oil recovery projects, 11 miscellaneous wells were reported as gas storage, and 4 as junked holes. The total footage drilled in these 83 miscellaneous wells was 240,889 feet, averaging 2,902 feet per well. Figure 17 shows a county breakdown of reported new miscellaneous well completions and old miscellaneous wells drilled deeper in 1990.

DRILLING AND COMPLETION COSTS

The costs of drilling and completing a well, given below in dollars per foot, vary with the company, drilling depth, method of completion, and geographic area. Costs generally increase yearly due to inflation, but they may decline if the prices for fossil fuels (needed in manufacturing and transporting casing, cement, etc.) decline. Prices typically increase as total depth increases, especially for wells that penetrate deeper, undrilled or untested formations. Dry holes are generally less expensive than producing wells because not as much is done to the hole beyond drilling and, perhaps, logging. Extremely deep wells may be extraordinarily expensive, not just because of increased rig time and increased casing, cementing, and other needs, but because provisions must be made for potential unforeseen problems. Wells drilled in untested formations and/or unexplored areas may require special testing and completion techniques as well. In Penn-

Figure 14. Reported new gas well completions and old gas wells drilled deeper in Pennsylvania, 1990.

REPORTED NEW GAS WELL COMPLETIONS			
County	No. of wells	Average initial open flow (Mcfgpd) ¹	Average total depth (feet)
Allegheny	7	423	4,254
Armstrong	72	342	3,475
Cambria	1	210	3,680
Centre	17	581	4,771
Clarion	10	71	2,349
Clearfield	22	566	3,968
Clinton	39	1,233	4,954
Crawford	32	1,210	4,957
Elk	10	117	2,349
Erie	15	837	2,706
Fayette	8	2,057	4,568
Forest	5	117	2,159
Greene	1	0	3,700
Indiana	124	822	3,723
Jefferson	46	490	3,302
McKean	6	137	2,465
Mercer	25	246	5,560
Somerset	2	3,950	9,222
Venango	73	344	5,575
Warren	71	1,271	5,211
Westmoreland	42	467	3,634
TOTAL	628	705	4,232

REPORTED OLD GAS WELLS DRILLED DEEPER			
County	No. of wells	Average initial open flow (Mcfgpd) ¹	Average amount deepened (feet)
Erie	1	100	1,207
Indiana	2	600	1,424
Jefferson	2	445	669
Westmoreland	1	330	38
TOTAL	6	420	905

¹Mcfgpd, thousand cubic feet of gas per day.

sylvania, an average well would be drilled to the Upper Devonian, about 2,530 feet deep (the average total depth of all wells reported in 1990). Deep wells (Lower Devonian Ridgeley Sandstone or Lower Silurian Medina Group) averaged 5,463 feet in 1990, and ultra-deep wells (deeper than 10,000 feet) averaged 13,494 feet.

Because drilling conditions and company policies vary widely, even within a small geographic area,

Figure 15. Reported new combination oil and gas well completions in Pennsylvania, 1990.

County	No. of wells	Average initial production (bopd) ¹	Average initial open flow (Mcfgpd) ²	Average total depth (feet)
Crawford	1	0	100	4,140
Forest	1	33.00	40	2,208
Mercer	40	0	1,002	5,643
Warren	3	0	87	3,194
TOTAL.....	45	.73	900	5,370

¹bopd, barrels of oil per day.

²Mcfgpd, thousand cubic feet of gas per day.

Figure 16. Reported new dry hole completions in Pennsylvania, 1990.

County	No. of dry holes	Average total depth (feet)
Allegheny	1	1,594
Armstrong	2	2,336
Cambria	1	9,091
Centre	4	4,705
Clarion	1	617
Clinton	1	4,920
Crawford	2	2,279
Elk	2	2,852
Erie	5	2,830
Fayette	1	2,917
Forest	1	1,240
Lawrence	2	850
Mercer	1	4,995
Somerset	4	8,675
Tioga	5	913
Westmoreland	1	4,137
TOTAL	34	3,482

the drilling costs listed are only estimates and should not be used as anything more than "ballpark" figures for the industry in 1990.

1. McKean County, shallow oil and gas well in the Bradford Group sandstones, about 1,400 feet deep. Dry hole,* about \$25,000. Completion, about \$50,000.
2. Elk County area, shallow oil well in the Bradford Group sandstones, about 2,400 feet deep. Dry hole,* about \$26,000. Completion, about \$46,000.

Figure 17. Reported new miscellaneous well completions and old miscellaneous wells drilled deeper in Pennsylvania, 1990.¹

REPORTED NEW MISCELLANEOUS WELL COMPLETIONS		
County	No. of wells	Average total depth (feet)
Clinton	2	6,739
Elk	69	2,516
Erie	3	2,088
Indiana	1	80
Potter	7	6,753
TOTAL	82	2,936

REPORTED OLD MISCELLANEOUS WELLS DRILLED DEEPER		
County	No. of wells	Average amount deepened (feet)
Tioga	1	162

¹Includes water intake, gas storage wells, and junked holes.

3. Elk County, shallow injection well in the Kane sand, about 2,400 feet deep. Dry hole,* about \$58,000. Completion, about \$103,000.
4. Indiana-Cambria-Clearfield County area, shallow gas well in the Bradford Group sandstones, about 3,500 feet deep. Dry hole,* about \$123,000. Completion, about \$135,000.
5. Fayette-Westmoreland County area, shallow gas well in the Bradford Group sandstones, about 4,000 feet deep. Dry hole,* about \$80,000. Completion, about \$140,000.
6. Centre-Clinton County area, shallow gas well in the Lock Haven Formation, about 4,900 feet deep. Dry hole,* about \$93,000. Completion, about \$191,000.
7. Crawford-Venango County area, deep gas well in the Medina Group sandstones, about 5,500 feet deep. Dry hole,* about \$110,000. Completion, about \$190,000.
8. Westmoreland-Somerset County area, deep gas well in the Ridgeley Sandstone, about 8,500 feet deep. Dry hole,* about \$315,000. Completion, about \$485,000.

*No completion attempted.

DEEP AND SHALLOW ACTIVITY

The Oil and Gas Geology Division of the Pennsylvania Bureau of Topographic and Geologic Survey classifies oil and gas wells as shallow or deep depending on the stratigraphic level penetrated rather than on actual depth. In general, wells that penetrate the top of the Tully Limestone or its equivalent (the presently accepted Upper-Middle Devonian boundary) are considered deep. Wells that do not penetrate the Tully horizon are generally considered shallow. The exceptions to this general rule involve formations of great significance, such as the rocks of the Mesozoic basins in southeastern Pennsylvania. Because the Appalachian basin is wedge shaped, absolute drilling depth is not instrumental in this classification. As such, a Lower Silurian Medina Group well along the shore of Lake Erie in Erie County may be only 2,500 feet deep, whereas an Upper Devonian Lock Haven Formation well in Centre County may be more than 5,000 feet deep. Yet, the Medina well is considered deep and the Lock Haven well is considered shallow on the basis of stratigraphic interval penetrated.

Shallow wells account for the greatest number of wells drilled in Pennsylvania; they may produce oil, gas, or both. Deep wells are rarer than shallow wells because of increased cost and risk; they most commonly produce gas, but there are numerous deep wells in northwestern Pennsylvania that also produce oil. Very few deep wells produce oil as their main, or sole, energy-mineral commodity. Figure 18 illustrates shallow-well drilling activity since 1950, and Figure 19 shows the changes in deep-well drilling activity during the period 1950–90.

There were 892 shallow wells reported in Pennsylvania in 1990, a decrease of 11 percent from the 999 wells reported in 1989. This 1990 total included 816 new oil, gas, combination, and dry wells, 5 old gas wells deepened, and 71 miscellaneous wells. In general, both the shallow oil wells and the shallow gas wells were drilled to Upper Devonian Venango and Bradford Group reservoirs. Subsidiary drilling in other shallow horizons resulted in production from (1) Pennsylvanian coals; (2) Lower Mississippian “Murrysville” sand; and (3) Upper Devonian Elk Group, Catskill and Lock Haven Formations, and Ohio Shale. Shallow-oil-well and/or shallow-gas-well drilling in Warren, Elk, Indiana, Armstrong, Jefferson, and Venango Counties accounted for 78 percent of all shallow drilling reported in 1990.

Reported deep drilling in Pennsylvania decreased 47 percent in 1990. During the year, only 281 deep wells were reported, down 247 wells from 1989. Deep drilling has not been this low since 1979, when only 175 deep wells were reported. The most active areas for deep drilling in Pennsylvania continued to be the northwestern counties of Warren, Venango, Crawford, and Mercer, accounting for 86 percent of all deep-well activity. Missing from this list of counties, however, is Erie, where only 17 wells were reported. Just 9 years ago, more wells were drilled in Erie County (284) than in all of Pennsylvania today. Deep formations drilled during 1990 for natural gas (and oil) production include the (1) Middle Devonian Huntersville Chert; (2) Lower Devonian Ridgeley Sandstone; (3) Upper Silurian Bass Islands Dolomite; (4) Lower Silurian Medina Group; and (5) Upper Ordovician Bald Eagle Formation.

Figure 20 shows the statistical breakdown for both shallow and deep wells reported in Pennsylvania in 1990. Figure 21 illustrates shallow- and deep-well drilling in terms of the final reported producing formations.

Shallow production totaled 137,960 Mmcf of gas and 2,531,887 bbl of oil, whereas deep production accounted for 39,649 Mmcf of gas and 90,162 bbl of oil. Figure 22 shows deep-gas production during the year by field and pool. In Figure 23, the information shown in Figure 22 is summarized by showing amounts of gas produced from the various deep reservoirs, both as an annual total and as a cumulative total. Figure 24 illustrates the amount of production, the yearly average unit price, and the yearly total value for all of the oil and gas produced in Pennsylvania since 1960.

PENNSYLVANIA DRILLING AND PRODUCTION RECORDS

The drilling depth record for Pennsylvania was set at 21,460 feet by the Amoco Production Company #1 Svetz well in Somerset County in 1974. The well penetrated Upper Cambrian rocks. This is also the deepest well drilled in the Appalachian basin. Although 1990 may have had an all-time low in the number of wells reported, it is ironically the year that the record for deepest production in Pennsylvania was broken. With the completion of the Felmont Oil Corporation #1 Pennsylvania State Tract 679 well in Clinton County, the new depth record for a producing well now stands at 13,253 feet. Pro-

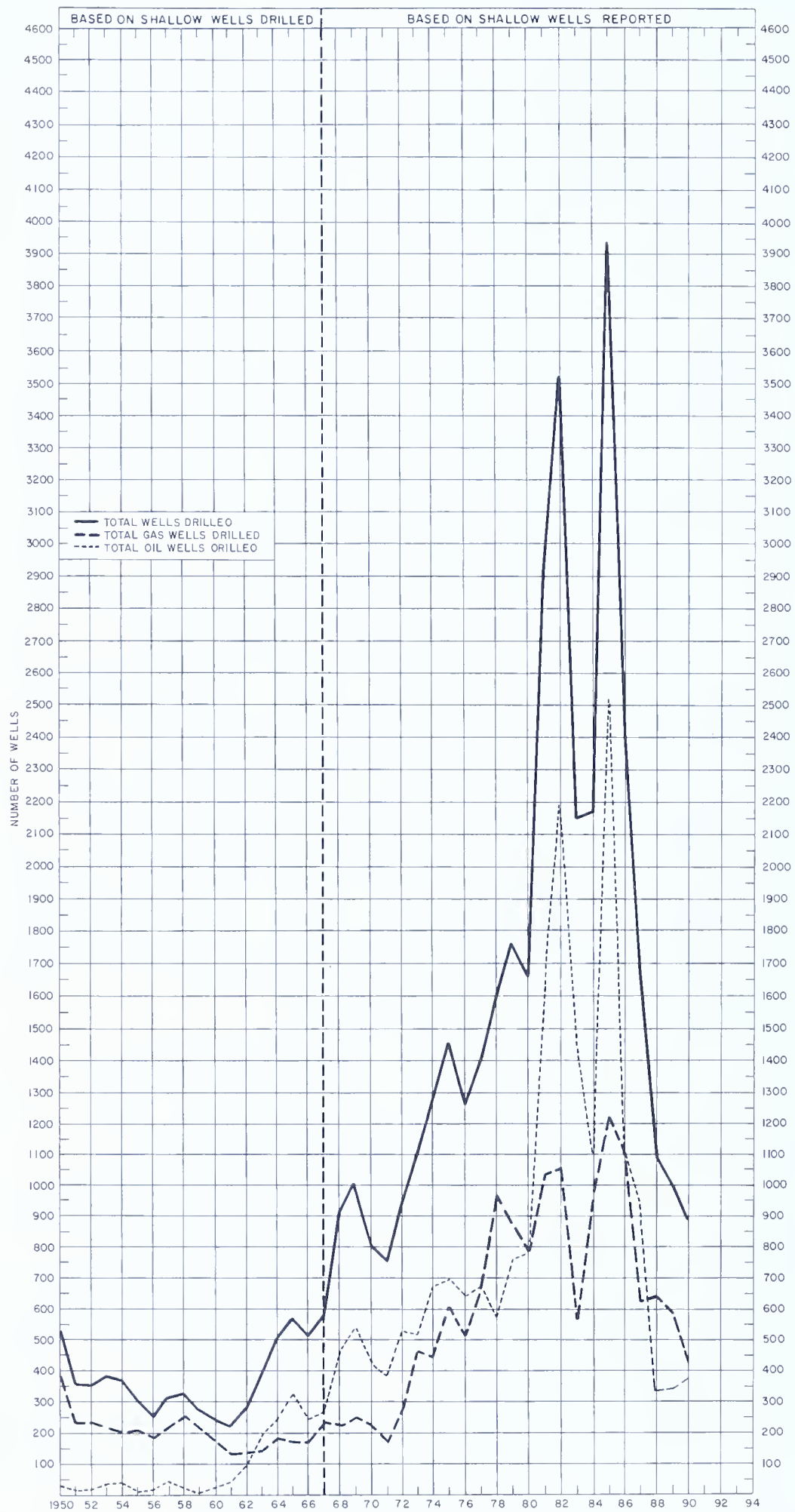


Figure 18. Shallow-well activity, 1950-90 (Late Devonian or younger producing horizons, generally less than 4,000 feet deep).

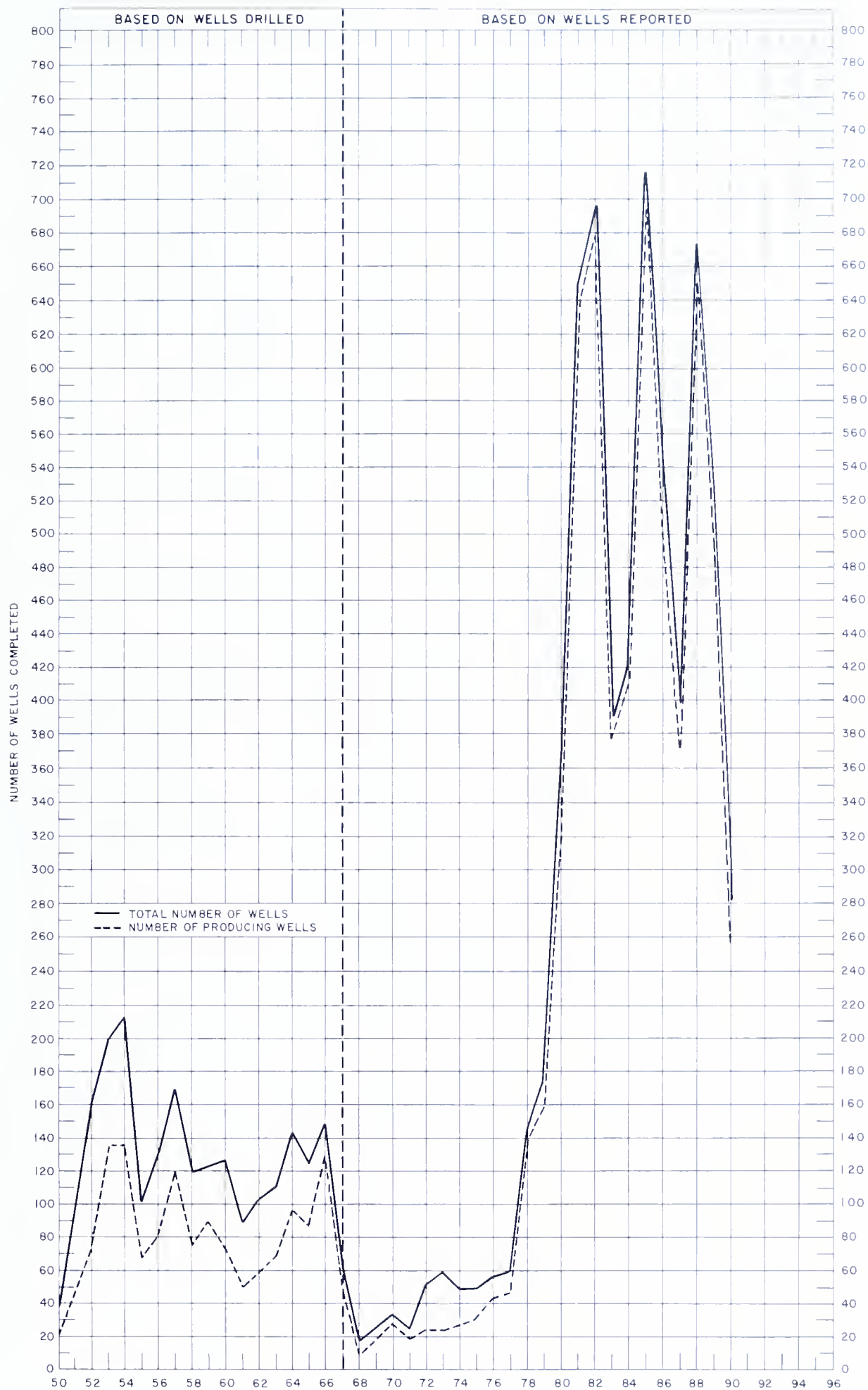


Figure 19. Annual rate of deep formation exploration and development, 1950-90 (Middle Devonian or older producing horizons, generally more than 4,000 feet deep).

Figure 20. *Reported drilling and completion of wells, 1990 (according to geologic age of producing horizons).*

<i>Shallow—Upper Devonian and younger</i>	
NEW WELLS	
Gas	414
Oil	376
Oil and gas	3
Dry	23
Total new wells	816
DEEPENED WELLS	
Gas	5
MISCELLANEOUS WELLS	
Water injection	68
Gas storage	1
Junked holes	2
Total miscellaneous wells	71
Total shallow wells	892
<i>Deep—Middle Devonian and older</i>	
NEW WELLS	
Gas	214
Oil	1
Oil and gas	42
Dry	11
Total new wells	268
DEEPENED WELLS	
Gas	1
MISCELLANEOUS WELLS	
Gas storage	9
Junked holes	2
Total miscellaneous wells	11
DEEPENED MISCELLANEOUS WELLS	
Gas storage	1
Total deep wells	281
TOTAL ALL WELLS DRILLED	1,173

duction in this well (as in the previous record holder) is from the Upper Ordovician Bald Eagle Formation. The record for largest initial production of gas for both Pennsylvania and the Appalachian basin is held by the New York State Natural Gas #1 Finnefrock well in the Leidy field, Clinton County. The well flowed 145,000 Mcfgpd without stimulation from the Lower Devonian Ridgeley Sandstone at 6,339 feet when drilled in 1951. The largest initial production for oil in Pennsylvania is, once again, an Appalachian basin record. The Jennings Brothers #1 Mathews well in the McDonald-McCurdy field, Allegheny County, reportedly flowed between 12,000

and 21,000 bopd (barrels of oil per day) from the Upper Devonian Venango Group ("Fifth sand") in 1891.

OIL AND GAS EXPLORATORY AND DEVELOPMENT ACTIVITIES

The Pennsylvania Bureau of Topographic and Geologic Survey, Oil and Gas Geology Division, uses a classification scheme for exploratory and development drilling that is modified from the definitions used by the Committee on Statistics of Drilling of the American Association of Petroleum Geologists. All wells reported here are the same as those reported under drilling and completions in the previous section of this report. In Figure 25, reported drilling activity in Pennsylvania in 1990 is summarized as exploratory, development, or miscellaneous.

EXPLORATORY WELLS

An exploratory well is one that is drilled to (1) find and produce oil or gas in unproven areas; (2) find a new reservoir in an area previously known to have oil and/or gas production in another reservoir; or (3) extend the known limit of a productive oil or gas reservoir. The exploratory categories are new field wildcats, new pool wildcats, deeper pool tests, shallower pool tests, and outpost/extension tests. If the well is drilled as an exploratory test and is not completed for production, it is classified as a dry exploratory hole.

Exploratory drilling in Pennsylvania accounted for 49 of the new well completions reported in Figure 25. Of these, 31 were productive, yielding a success rate of 63 percent. It should be pointed out that "success" simply means that the well was completed for production without specific reference to long-term economic viability. Figure 26 shows the breakdown of exploratory drilling by classification. All exploratory successes and the more important exploratory failures reported in 1990 are illustrated in Figure 27, and these wells are listed in Figures 28 and 29.

DEVELOPMENT WELLS

A development well is one that is drilled within a proven area of production to a known productive stratigraphic horizon. A producing well in such

Figure 21. Reported oil and gas well completions in Pennsylvania by shallow and deep producing formations, 1990.

Producing formation		Oil wells	Gas wells	Combination oil and gas wells	Gas storage wells	Total wells
S H A L L O W	Mississippian	2	4	0	0	6
	Mississippian/Venango	0	1	0	0	1
	Mississippian/Bradford	0	1	0	0	1
	Venango	50	10	0	1	61
	Venango/Bradford	0	118	0	0	118
	Bradford	324	¹ 210	3	0	537
	Bradford/Elk	0	12	0	0	12
	Elk	0	3	0	0	3
	Catskill	0	1	0	0	1
D E E P	Lock Haven	0	54	0	0	54
	Ohio Shale	0	6	0	0	6
	Subtotal	376	420	3	1	800
	Huntersville	0	2	0	0	2
	Ridgeley	0	3	0	10	13
	Bass Islands	1	0	0	0	1
	Medina	0	208	42	0	250
	Bald Eagle	0	1	0	0	1
	Subtotal	1	214	42	10	267
GRAND TOTAL		377	634	45	11	1,067

¹Includes one deep well plugged back and producing shallow.

Figure 22. Gas production from rocks of Middle Devonian or older age in Pennsylvania, 1990 (classified as "deep" production).

Field	Pool	County	Discovery date	Production 1990 (Mcf) ¹	Cumulative production at end of 1990 (Mcf) ¹	Reservoir ²
Alder Run		Erie	8/24/74	15,978	495,929	M
Athens		Crawford	9/20/74	134,040	2,025,137	M
	Brimstone	do.	1/30/79	735,808	5,995,796	M
	Dutch Hill	do.	8/31/80	213,006	2,588,548	M
	Lincolnville	do.	8/16/80	41,753	546,358	M
	Potash Run	do.	3/18/79	42,986	505,490	M
	Rome	do.	6/ 9/79	597,179	5,133,937	M
Big Bend	Lackawannock	Mercer	3/ 4/90	61,463	61,463	M
Black Ash	Motter	Crawford	3/ 7/86	119,773	349,021	M
Blooming Valley		do.	2/11/82	180	125,112	M
Blue Hole		Somerset	2/ 6/89	59,473	91,503	HR
Bradford	Cyclone	McKean	2/18/74	24,257	2,266,473	N
Breedtown	Gresham	Crawford, Venango	10/ 5/85	1,108,833	3,800,378	M
Brier Knob		Somerset	7/22/80	194,676	194,676	R
Brokenstraw		Erie, Warren	7/27/78	29,559	193,451	M
	Stroup	do.	7/28/80	30,582	239,675	M
Cambridge Springs		Crawford, Erie	1/31/76	329,173	2,073,055	M
	Cambridge	Crawford	4/ 6/76	30,300	254,905	M

Figure 22. (Continued).

<i>Field</i>	<i>Pool</i>	<i>County</i>	<i>Discovery date</i>	<i>Production 1990 (Mcf)¹</i>	<i>Cumulative production at end of 1990 (Mcf)¹</i>	<i>Reservoir²</i>
Carter Hill		Erie	5/14/79	99,105	1,129,229	M
	Macedonia	do.	4/20/84	61,807	617,504	N,H
Church Run	Bates Hollow	Crawford	4/ 8/85	54,860	403,824	M
	Gilson Ridge	do.	11/25/87	11,284	50,969	M
	Hatchtown	Crawford, Warren	6/27/79	273,527	2,409,751	M
	Vrooman	do.	12/ 7/79	865,054	6,496,332	M
Cochranon		Crawford, Mercer, Venango	11/16/80	581,405	7,491,226	M
	Deckard	Crawford, Venango	11/ 4/80	201,761	1,260,552	M
	McDaniels	Crawford, Mercer	3/16/81	70,170	1,322,309	M
Colorado	Seldom Seen	Warren	1/11/84	272,434	1,397,787	M
Columbus	Dewey Corners	do.	2/10/81	864,415	6,599,551	M
	Hare Creek	Erie, Warren	6/26/81	6,797	165,793	M
	Horn Siding	Warren	3/21/89	24,700	24,700	M
	Whites Run	do.	10/30/75	986,237	2,377,011	M
Concord	Harbor Ridge	Erie	10/ 2/79	6,663	46,709	M
	Stewart Road	do.	3/10/80	28,961	102,548	M
Conneaut	Beaver Creek	Crawford	9/26/81	5,102	78,954	M
	Blood	do.	12/17/80	141,283	1,515,591	M
	Bushnell-Lexington	Crawford, Erie	12/31/58	240,987	20,981,261	M
	Carlson	Crawford	2/23/81	145,574	2,263,327	M
	Forro	do.	1/ 4/58	6,875	56,231	M
	Indian Springs	do.	9/11/57	491,917	25,764,873	M
	Kastle	do.	7/14/62	137,372	3,817,101	M
	Lundys Lane	Crawford, Erie	11/ 9/61	202,487	7,448,193	M
	Mud Run	Crawford	11/ 5/81	9,073	116,345	M
	Pageville	Crawford, Erie	10/10/80	28,746	688,156	M
	Pennside	do.	9/ 9/59	20,152	401,427	M
	Pierce	Erie	12/31/58	3,754	924,957	M
	Rogers	Crawford, Erie	4/ 8/82	5,034	53,603	O
	Springboro	Crawford	11/ 7/79	18,350	494,763	M
	Stone Run	do.	10/21/79	10,393	1,026,494	M
	West Mead	do.	7/ 8/74	5,919	64,956	M
Conneaut Lake		do.	8/ 9/82	11,373	153,995	M
Coolspring	Filer Corners	Mercer	8/ 8/83	9,070	57,122	M
Cooperstown	Beatty Run	Crawford, Venango	7/30/82	6,346,459	35,463,587	M
	Donation Hill	Venango	7/28/88	20,051	76,338	L
Corry		Erie	4/29/47	46,024	544,782	M
	Beaver Dam	do.	5/20/53	10	362,150	M
	Spencer Creek	do.	6/19/70	35,495	316,163	M
County Line		Crawford, Warren	1/31/81	441,086	1,694,490	M
Cussewago		Crawford, Erie	6/17/81	84,378	659,100	M
Davy Hill	Pittsfield	Erie, Warren	9/17/85	346	9,057	M
	Ross Hill	Warren	9/26/84	1,864	4,659	BK
Dempseytown	Mt. Carmel	Venango	10/ 6/86	301,423	1,197,448	M
Dotyville	Porky Run	Crawford, Warren	11/ 5/86	264,288	1,389,784	M
Drumlin	Greenley	Erie	10/11/83	2,297	869,457	H
	Swails	do.	6/27/80	116,660	4,675,651	M
East Emporium		Cameron	11/17/71	102,290	5,212,784	R
Eaton Corners	Brown Hill	Crawford	11/15/81	47,076	507,799	M
Edinboro		Crawford, Erie	7/28/80	51,851	1,216,578	M
Edinboro North		do.	1/ 9/80	286,891	5,541,922	M
	Conneauttee	Erie	10/14/82	991	45,512	S
Enterprise	Kirvan	Venango, Warren	8/23/84	181,185	997,040	M
Erie	Bartosic	Erie	3/ 7/79	16,927	301,169	O
	Blass	do.	2/12/66	1,815	13,913	M
	Brandy Run	do.	5/28/79	5,827	5,975	M
	Charter Oaks	do.	5/19/77	75,581	803,952	M

Figure 22. (Continued).

<i>Field</i>	<i>Pool</i>	<i>County</i>	<i>Discovery date</i>	<i>Production 1990 (Mcf)¹</i>	<i>Cumulative production at end of 1990 (Mcf)¹</i>	<i>Reservoir²</i>
Erie	Dunn Valley	Erie	1/19/80	6,243	178,273	M
	Fairview	do.	3/12/76	147	8,967	M
	Glenwood	do.	8/ 9/77	1,194	215,962	M
	Goddard	do.	8/31/78	10,958	473,794	M
	Lawrence Park	do.	8/30/77	8,562	34,206	M
	Oliver Road	do.	3/24/85	1,500	1,500	N
	School	do.	5/21/84	211,109	432,625	O
	Talcott	do.	7/ 8/79	33,122	1,771,639	M
Fauncetown	Crawther	Crawford	9/16/86	96,636	489,328	M
Franklin Center.....		Erie	6/16/80	2,267,155	3,453,006	M
Franklin-Oak Forest...	Galloway	Venango	11/12/73	272,996	1,035,011	M
Frenchtown		Crawford	8/17/80	11,184	105,111	M
	Mt. Hope	do.	10/31/80	4,957	4,957	M
Frostburg	Elk Run	Jefferson	6/20/65	37,888	49,925,879	R
Geneva	Greenwood	Crawford	10/31/73	53,462	546,208	M
	Rock Creek	do.	6/27/77	52,577	905,898	M
Gifford Run		Clearfield	1/13/83	259,940	3,148,449	R
Goodwill Hill-						
Grand Valley	Campbell Creek	Warren	11/14/81	1,451,902	7,071,703	M
Greenfield		Mercer	5/17/84	1,208,782	3,988,732	M
Greenville	Thiel	do.	10/28/81	13,004	110,268	M
Grugan		Clinton, Lycoming	12/13/82	1,087,696	6,776,333	BE
Hadley	Perry School	Mercer	8/30/81	6,941	112,601	M
Hamilton Corners.....	Tecza	Venango	7/ 4/86	1,798,416	4,194,092	M
Hicks Run		Cameron, Elk	6/ 7/56	1,079	4,438,304	R
Kantz Corners.....		Crawford, Mercer	7/26/77	1,705,230	23,358,714	M
	Barco	Crawford	12/13/80	1,003	37,647	M
	East Fairfield	do.	7/31/80	83,493	1,465,221	M
	Mt. Pleasant Road	do.	8/30/80	10,651	209,218	M
	Round Knob	do.	11/12/80	58,854	1,111,244	M
	Shaws Corners	do.	7/15/80	132,490	2,198,868	M
Lake Creek	Wilson Mills	Crawford, Venango	12/22/84	1,722,582	6,174,014	M
LeBoeuf	Waterford	Erie	3/21/77	99,845	6,344,110	M
Linn Run		Westmoreland	4/25/79	89,980	942,009	R
	Silver Mine	Somerset,	4/ 2/87	109,816	823,327	HR
		Westmoreland				
Maysville		Mercer	11/11/77	19,471	78,408	M
	West Salem	do.	2/17/81	47,564	207,532	M
McCune Run.....	Canal	Venango	5/25/82	1,019,704	6,875,943	M
Mill Village		Erie	7/27/79	47,387	5,805,655	M
Mt. Davis.....		Somerset	7/20/88	47,063	372,609	HR
	Tub Mill	do.	12/19/88	11,722	35,624	HU
New Hamburg.....	Goodhope	Mercer	2/ 2/79	43,457	201,333	M
New Ireland.....		Erie	5/14/78	5,654	1,447,916	M
North East	Bailey Brook	do.	1/11/80	165,183	2,898,315	M
	Bull Reservoir	do.	9/17/72	126,218	1,713,941	M
	Burgess	do.	10/17/60	103,659	3,652,855	M
	Delhill Corners	do.	6/23/79	624,582	1,560,214	N
	Harborcreek	do.	10/20/77	72,175	1,509,253	M
	Hornby	do.	6/10/78	55,583	2,156,739	M
	Kuhl	do.	8/14/78	14,189	88,218	M
	Little Hope	do.	12/ 7/78	2,929	107,794	M
	McGuire	do.	2/ 8/80	104,756	307,894	O
	Meabon	do.	5/15/86	20,055	339,399	N
	Orchard Beach	do.	2/18/74	128,730	3,862,520	M
	Wattsburg	do.	4/19/80	27,490	290,684	M
Oakland	Splane	Venango	9/22/85	66,394	219,908	M
Papenfuse.....		Crawford	11/16/80	13,424	308,740	M

Figure 22. (Continued).

<i>Field</i>	<i>Pool</i>	<i>County</i>	<i>Discovery date</i>	<i>Production 1990 (Mcf)¹</i>	<i>Cumulative production at end of 1990 (Mcf)¹</i>	<i>Reservoir²</i>
Penfield	Sabula	Clearfield, Elk	9/18/58	7,328	2,839,331	R
Phillipsville	Dennee	Erie	7/14/81	68,170	481,975	M
Picadilli	Turn Hill	Warren	11/18/88	12,350	18,954	M
Pleasantville	Neilltown	Venango	3/10/85	20,933	33,604	M
Pot Ridge		Cambria	7/ 1/81	41,177	41,177	R
Punxsutawney- Driftwood	Benezette	Cameron, Clearfield, Elk	1/ 5/53	51,225	252,242,717	R
	Driftwood	do.	9/15/51	38,879		
	Parker Dam	Clearfield	3/16/88	59,957	112,433	R
	Helvetia	Clearfield, Elk	5/11/60	0	4132,970,841	R
	Rockton	do.	2/25/55	50,558		
	Reed-Deemer ³	do.	12/ 1/53	0		
Queen Junction	Creel	Butler	9/28/87	824	2,283	TL
	Elora	do.	7/27/86	3,800	3,800	R
Reeds Corners		Erie	7/ 9/80	84,908	1,379,487	M
Richmond Township ..	Woodcock	Crawford	7/21/81	23,097	97,857	M
	Zirkle	do.	6/22/81	8,054	57,260	M
Rockdale		do.	11/30/79	473,400	3,626,389	M
Sandy Creek	Quebec Run	Fayette	6/ 3/69	884	49,061	H
Sanford	Trimm	Warren	2/19/81	684,117	2,470,858	M
Selkirk	Three Bridge	Crawford, Warren	2/28/81	458,790	2,759,790	M
Seven Springs	Blair Oriskany	Westmoreland	12/ 5/58	34,785	6,732,373	R
	Tunnel	do.	3/10/65	0		
	Distillery	Somerset	9/20/87	59,560	481,274	HR
	Laurel Hill	do.	3/ 5/81	45,130	517,409	R
	Lookout	do.	1/14/87	182,490	884,526	HR
	Myersbrook	Westmoreland	7/16/82	4,044	664,174	R
	Seven Springs	Somerset	8/ 3/66	7,574	866,468	R
	Weaver Road	do.	3/15/84	68,088	1,394,552	R
Shamburg	Jerusalem Corners	Crawford, Venango	7/ 1/85	21,460	154,868	M
Sharon	Sharon Deep	Mercer	2/26/78	1,236,726	5,210,239	M
Sheakleyville		do.	5/12/81	81,028	1,175,613	M
Sparta	Eastman Hill	Crawford	10/30/75	192,571	310,520	M
Spring Creek	West Spring Creek	Warren	6/15/84	302,406	737,977	M
Stillwater		do.	11/ 3/78	4,104	689,458	M
	Freehold	do.	8/ 5/80	25,507	517,068	M
Stoneboro	Lake	Mercer	3/ 2/83	23,054	153,640	M
Sugar Creek-Niles	Takitezy	Venango	7/26/82	199,349	1,004,341	M
Sugar Grove	Mikrut	Warren	7/21/81	447	10,607	M
Tidioute	Cochene	do.	2/ 1/86	2,690	16,541	M
Toonerville	Cherrytree Run	Venango	3/10/87	374,461	786,314	M
Troy	Diamond	Crawford, Venango	9/18/87	477,600	917,141	M
Union City	Emmons	Erie	12/30/80	22,140	171,118	M
Utica	French Creek	Mercer, Venango	7/26/81	67,268	384,348	M
Wheatland		Mercer	7/24/63	269,706	2,694,063	M
Whippoorwill		Cameron, Elk	7/10/61	39,978	16,580,038	R
Wolf Creek	Kilgore	Mercer	10/26/66	29,591	5,798,800	L
Youngsville	Pikes Rocks	Warren	2/19/81	3,492	162,265	M

¹Mcf, thousand cubic feet.²TL, Tully Limestone; N, Onondaga Limestone; HU, Huntersville Chert; HR, Huntersville Chert/Ridgeley Sandstone; O, Oriskany Sandstone; R, Ridgeley Sandstone; H, Helderberg Group; S, Salina Group; L, Lockport Dolomite; M, Medina Group; BE, Bald Eagle Formation; BK, Beekmantown Formation.³Reed-Deemer is a pool in the Big Run field, however, production is commingled with the Rockton and Helvetia pools.⁴Corrected figure.

Figure 23. Deep gas production in Pennsylvania in 1990 by producing formation.

<i>Producing formation</i>	<i>Production in 1990 (Mcf)¹</i>	<i>Cumulative production at end of 1990 (Mcf)^{1,2}</i>
Tully Limestone.....	824	2,283
Marcellus Formation (deep black shale)	0	75,930
Onondaga Limestone	673,465	4,696,630
Oriskany Sandstone, Huntersville Chert, and Ridgeley Sandstone ...	1,947,057	1,322,597,942
Bass Islands Dolomite and Helderberg Group	35,379	1,461,855
Salina Group	991	45,512
Lockport Dolomite	49,642	5,903,585
Medina Group	35,813,233	313,541,031
Tuscarora Sandstone	0	3,886,966
Bald Eagle Formation	1,087,696	6,608,449
Beekmantown Formation.....	1,864	4,659
Gatesburg Formation and Little Falls Dolomite	0	207,200
TOTAL	39,610,151	1,659,032,042

¹Mcf, thousand cubic feet.

²Includes production from previous years reported in 1990.

an area and reservoir is classified as an oil or gas development well. It is considered a dry development well if it is not completed for production.

Development drilling declined 27 percent from 1989; only 1,041 wells were reported drilled in 1990, marking an all-time low for the past 17 years. The success rate for all development drilling remained high at 98 percent.

HIGHLIGHTS OF 1990 EXPLORATION AND DEVELOPMENT

As in previous years, shallow-oil-well and shallow-gas-well drilling dominated oil- and gas-well drilling activity in Pennsylvania in 1990. More than 76 percent of all wells reported during the year (892 wells) fell into this category. Shallow targets in Pennsylvania include the numerous prolific Upper Devonian sandstone reservoirs of the Venango, Bradford, and Elk Groups in western Pennsylvania and the Lock Haven Formation in the north-central part of the state (Figure 30). Several shallower units, such as certain Pennsylvanian coals and Mississippian sandstones, act as subsidiary reservoirs in southwestern Pennsylvania. Some deeper Upper Devonian reservoirs, such as the Catskill and Brallier Formations and the Ohio Shale of Erie County, may also account for additional production during any given year.

Shallow-well activity reported in Pennsylvania in 1990 was dominated by development drilling and included the completion of 799 productive wells and 1 gas storage well (Figure 21). Very little exploratory activity occurs in the shallower horizons in Pennsylvania, and most of the wells that qualify as exploratory are merely extensions of known production. However, as if to justify the old adage of the exception proving the rule, the oil and gas industry reported seven shallow new field wildcats in 1990, all of which were completed as dry holes (Figure 29).

Charles L. Steen drilled the #1 McMillin well in Scott Township, Lawrence County, to a depth of 915 feet. The well had shows of gas in the Berea Sandstone and the Venango Group, but the possibility of production was eliminated when salt water was encountered in the Berea. Four dry holes in the Catskill and/or Lock Haven Formations in Delmar Township, Tioga County, were reported, including the Rex E. Willard #A-1 Kendrick, Rex E. Willard #A-1 Torpy, Rex E. Willard #A-5 Davis, and G. C. Young, Inc. #A-3 Kendrick. Of these four, two were abandoned before drilling was completed. The W. F. Glover #1 State Forest Lands well in Gaines Township, Tioga County, suspended drilling at 1,617 feet in the Lock Haven. It had a show of oil at 780 feet and a show of gas at 1,005 feet. The seventh shallow new field wildcat was the Eastern States Exploration Company #2 Commonwealth of Pennsylvania Tract 252 in Bald Eagle Township,

Figure 24. *Production, unit price, and total value of crude oil and natural gas produced in Pennsylvania, 1960–90.*

Year	CRUDE OIL			NATURAL GAS			Total oil and gas value (dollars)
	Production ¹ (bbl)	Average yearly price (dollars/bbl)	Total value (dollars)	Production ² (Mcf) ⁴	Average yearly price ³ (dollars/Mcf) ⁴	Total value (dollars)	
1960	5,942,000	4.57	27,154,940	119,671,000	0.26	31,114,460	58,269,400
1961	5,580,000	4.76	26,560,800	98,318,000	.26	25,562,680	52,123,480
1962	5,238,000	4.63	24,251,940	87,308,000	.26	22,700,080	46,952,020
1963	5,014,000	4.63	23,214,820	92,340,000	.26	24,008,400	47,223,220
1964	5,113,000	4.48	22,906,240	85,322,000	.26	22,183,720	45,089,960
1965	4,859,000	4.20	20,407,800	82,668,000	.26	21,493,680	41,901,480
1966	4,349,000	4.33	18,831,170	91,365,000	.26	23,754,900	42,586,070
1967	4,409,000	4.35	19,179,150	89,966,000	.26	23,391,160	42,570,310
1968	4,160,000	4.35	18,096,000	87,987,000	.28	24,636,360	42,732,360
1969	4,448,000	4.29	19,081,920	79,134,000	.26	20,574,840	39,656,760
1970	4,015,000	4.27	17,144,050	77,535,000	.27	20,934,450	38,078,500
1971	3,798,000	4.47	16,977,060	76,451,000	.30	22,935,300	39,912,360
1972	3,441,000	4.60	15,828,600	73,958,000	.45	33,281,100	49,109,700
1973	3,282,000	5.73	18,805,860	78,514,000	.45	35,331,300	54,137,160
1974	3,399,000	8.43	28,653,570	82,735,000	.50	41,367,500	70,021,070
1975	3,199,000	9.26	29,622,740	84,772,000	.80	67,817,600	97,440,340
1976	2,950,000	11.51	33,954,500	89,974,000	.85	76,477,900	110,432,400
1977	2,659,000	14.22	37,810,980	92,293,000	1.00	92,293,000	130,103,980
1978	2,820,000	14.77	41,651,400	97,763,000	1.25	122,203,750	163,855,150
1979	2,817,000	23.67	66,678,390	96,313,000	1.40	134,838,200	201,516,590
1980	2,940,000	37.42	110,014,800	97,439,000	1.50	146,158,500	256,173,300
1981	3,729,000	36.33	135,474,570	122,454,000	2.00	244,908,000	380,382,570
1982	4,282,000	31.42	134,540,440	121,111,000	2.80	339,110,800	473,651,240
1983	4,491,000	28.18	126,556,380	118,372,000	3.00	355,116,000	481,672,380
1984	4,825,000	27.64	133,363,000	166,342,000	3.25	540,611,500	673,974,500
1985	4,851,000	25.12	121,857,120	150,541,000	3.15	474,204,150	596,061,270
1986	3,783,000	15.66	59,241,780	159,889,000	2.50	399,722,500	458,965,642
1987	3,302,000	17.23	56,893,460	163,318,000	2.25	367,465,500	424,358,960
1988	2,807,000	15.22	42,722,540	167,089,000	2.25	375,950,250	418,672,790
1989	⁵ 2,602,000	18.10	⁵ 47,096,200	191,774,000	2.40	460,257,600	⁵ 507,353,800
1990	2,601,000	22.94	59,666,940	177,609,000	2.35	417,381,150	477,048,090

¹Oil production figures courtesy of Pennsylvania's oil producers.²Gas production figures courtesy of the American Gas Association.³Gas prices estimated only.⁴Mcf, thousand cubic feet.⁵Corrected figure.

Clinton County. The well reached 4,920 feet before being plugged and abandoned without a show of gas at any level.

Deep drilling in the Commonwealth has always been subsidiary to shallow drilling, even in the 1950's when the industry drilled thousands of wells in the Lower Devonian Ridgeley Sandstone (Figure 31) throughout north-central Pennsylvania. This trend continued in 1990 with only 281 deep wells, less than 24 percent of the total number of wells, reported during the year. Of this figure, 257 were producing wells, and 10 were completed as gas storage wells (Figure 21). Despite the relative lack of numbers, however, deep wells are commonly

considered more important than shallow wells because they are more likely to lead to the discovery of new reservoirs, establish higher reserves, and add to our knowledge of subsurface geology. The more commonly drilled deep horizons in Pennsylvania include the Middle Devonian Huntersville Chert and Lower Devonian Ridgeley Sandstone in the eastern Plateau area and the Lower Silurian Medina Group in the northwestern part of the state (Figure 31). The carbonate and evaporite rock sequence between the Middle Devonian Onondaga Limestone and Middle Silurian Lockport Dolomite in northwestern Pennsylvania, the Upper Ordovician Bald Eagle Formation in north-central Pennsylvania, and the

Figure 25. *Reported exploratory and primary development and drilling footages, 1990 and 1989.*

<i>Type of well</i>	<i>1990 Wells</i>	<i>1990 Footage</i>	<i>1989 Wells</i>	<i>1989 Footage</i>	<i>Percent change in footage</i>
Exploratory					
Gas	25	150,097	43	253,776	
Oil and gas	6	34,126	1	2,734	
Dry	18	75,847	24	157,488	
Total (percent successful)	49 (63%)	260,070	68 (65%)	413,998	- 37
Development					
Gas	609	2,513,220	1,012	4,301,063	
Oil	377	535,905	329	475,916	
Oil and gas	39	207,504	48	195,321	
Dry	16	42,529	40	159,807	
Total (percent successful)	1,041 (98%)	3,299,158	1,429 (97%)	5,132,107	- 36
Miscellaneous					
Water intake	68	170,138	18	45,089	
Gas injection	0	0	1	900	
Stratigraphic core tests	0	0	1	2,485	
Gas storage	11	64,408	6	25,601	
Junked	4	6,343	4	530	
Total	83	240,889	30	74,605	+ 223
TOTAL ALL WELLS DRILLED	1,173 (97%)	3,800,117	1,527 (96%)	5,620,710	- 32

Figure 26. *Reported exploratory drilling in Pennsylvania by classification and type of well, 1990.*

<i>Classification and type of well</i>	<i>No. of wells</i>	<i>Footage</i>
NEW FIELD WILDCATS		
Gas	2	13,178
Dry	9	22,890
Subtotal	11	36,068
NEW POOL WILDCATS		
Gas	2	15,196
Oil and gas	1	5,630
Dry	4	28,753
Subtotal	7	49,579
DEEPER POOL TESTS		
Gas	2	11,973
Subtotal	2	11,973
OUTPOST EXTENSIONS		
Gas	19	109,750
Oil and gas	5	28,496
Dry	5	24,204
Subtotal	29	162,450
GRAND TOTAL EXPLORATORY WELLS	49	260,070

Upper Cambrian Gatesburg Formation in the northwestern part of the state are the main subsidiary targets of deep drilling. Shale-gas production from the Middle Devonian Marcellus Formation occurs sparsely, and it is commonly lumped with Upper Devonian shale gas as shallow production.

The Middle Devonian Onondaga Limestone produces in only a few places in northwestern Pennsylvania, most often in conjunction with the highly fractured rocks of the "Bass Islands trend" (see p. 47). This trend is misnamed because, in Pennsylvania, production comes from the Onondaga Limestone, Lower Devonian Manlius Limestone (Helderberg Group), Upper Silurian Bass Islands Dolomite, and Upper Silurian Salina Group carbonates rather than from the Bass Islands alone. Most Onondaga pools are very small, one-well pools having limited production. One pool, however, the Meabon pool in the North East field, Erie County, is a multiwell reservoir that has produced both oil and gas since 1986, and new wells are reported almost every year. Very few exploratory wells in the Onondaga are reported in any particular year. In 1990, Dominick A. DiRienzo submitted the record for his #1 DiRienzo well, a new pool wildcat in the Erie field that reached a total depth in the

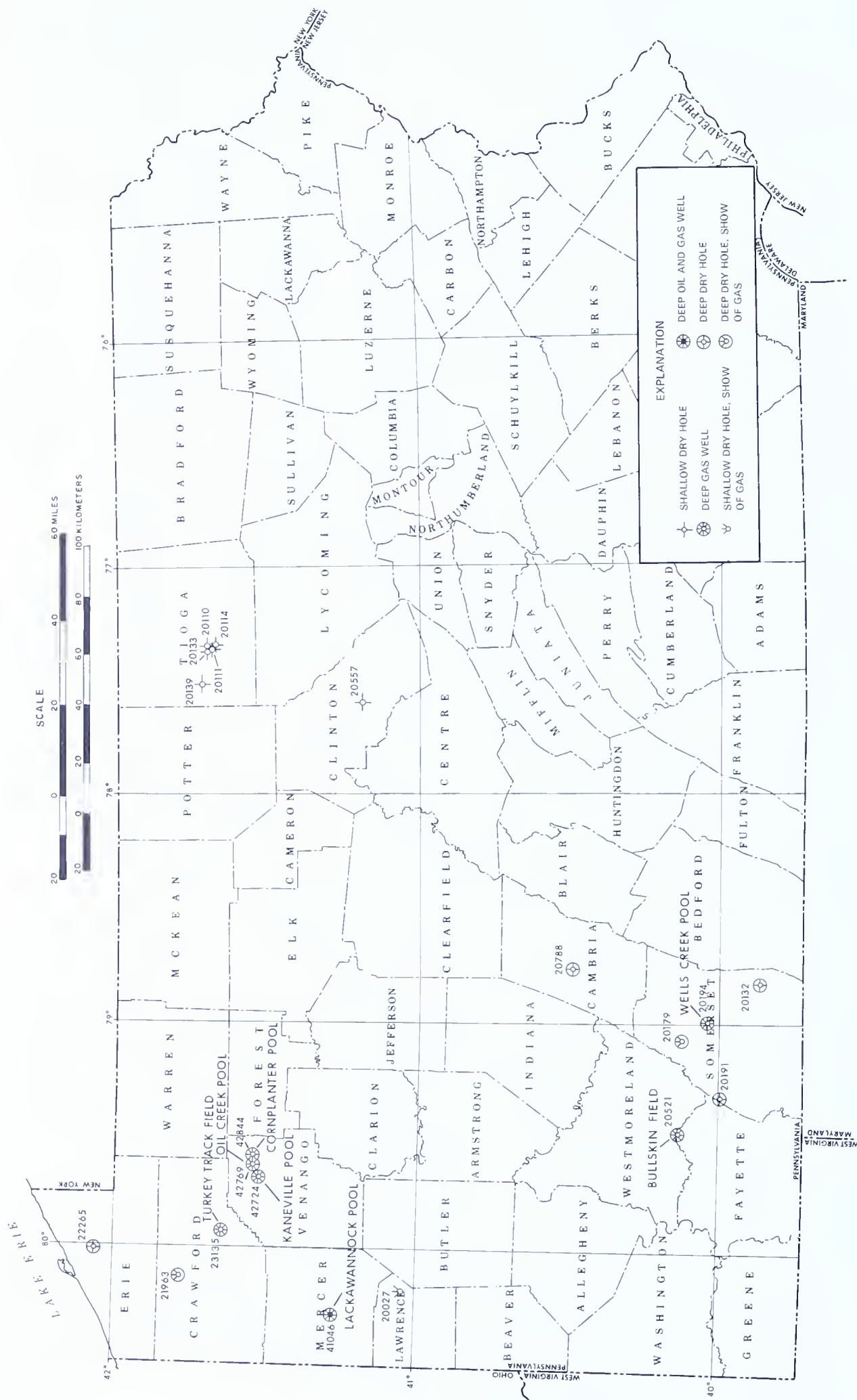


Figure 27. Exploratory wells in Pennsylvania reported in 1990.

Figure 28. Reported new field and new pool discoveries in Pennsylvania, 1990.

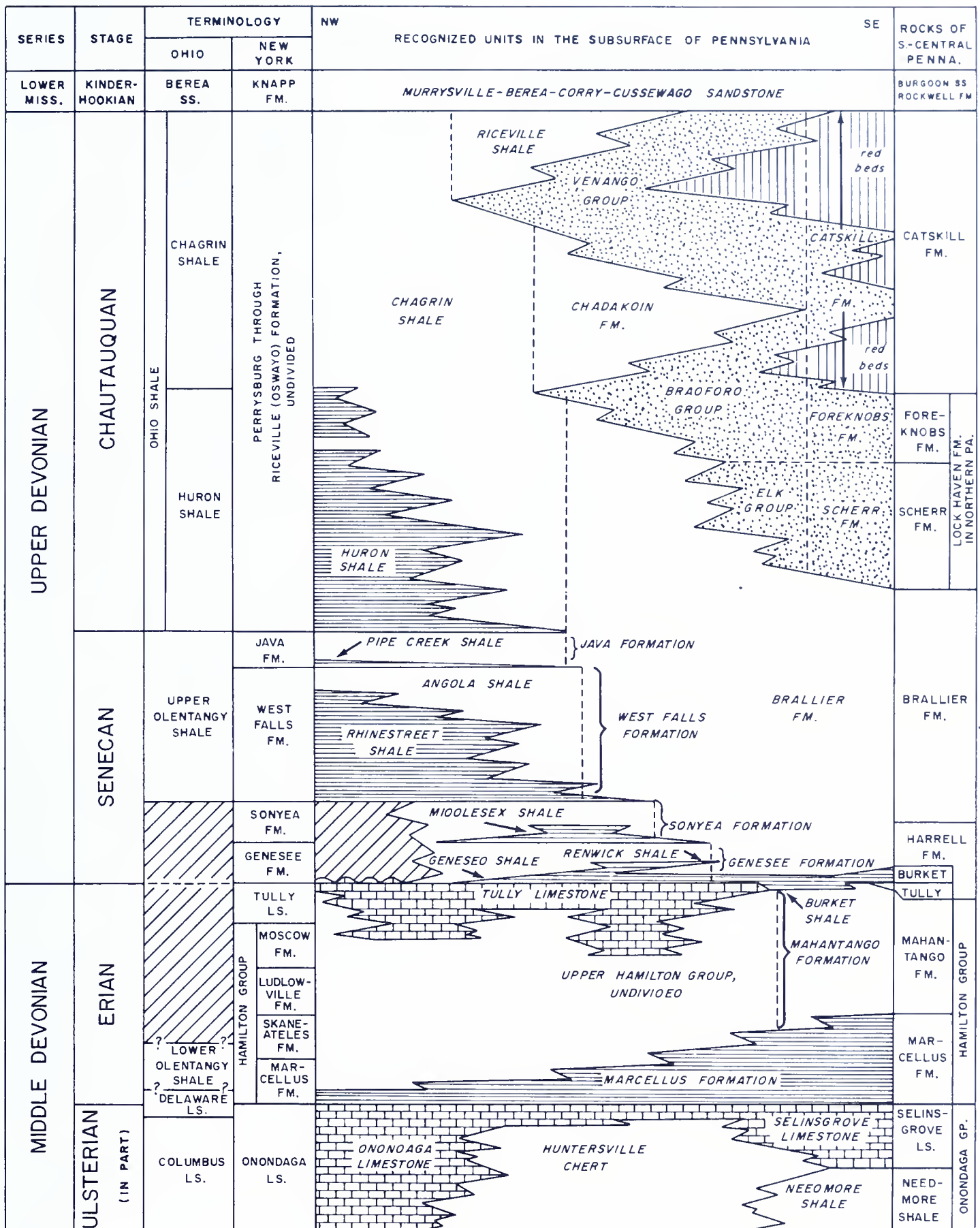
County and permit no.	Quadrangle	Operator Well no. and lease	Completion date	Total depth (feet)	Formation or group at T.D. ²	Prod. depth (feet)	Producing formation or group ²	Initial daily prod. (Mcf) ³	Field or pool (and field) name	Explor. class ¹ and type of well
Crawford 039-23135	Townville	Quaker State Corp. Gilbert, Karl #1	12/ 9/89	5,280	Queenston (O)	5,127	Medina (S)	1,800	Turkey Frack field	NPD
Fayette 051-20521	Mammoth	CNG Producing Co. Kleinbrook, E. #1	8/ 2/90	7,898	Helderberg (D)	7,753	Ridgeley (D)	6,000	Bullskin field	Gas
Mercer 085-21046	Fredonia	Atlas Resources, Inc. Cupic, W. & S. #1	3/22/90	5,630	Queenston (O)	5,522	Medina (S)	1,090	Lackawannock pool (Big Bend)	Gas
Somerset 111-20194	Stoystown	CNG Producing Co. Skeria, V. #1-4155	1/21/90	9,314	Helderberg (D)	9,162	Ridgeley (D)	5,000	Wells Creek pool (Shanksville)	NPD
Venango 121-42724	Titusville South	Mark Resources Corp. CP Unit #19-1	11/21/89	5,882	Queenston (O)	5,777	Medina (S)	115	Kaneville pool (Petroleum Center-Pioneer)	Gas
Venango 121-42769	Titusville South	Quaker State Corp. Goodlett, Rensma #1	12/ 1/89	6,015	Queenston (O)	5,862	Medina (S)	1,600	Oil Creek pool (Petroleum Center-Pioneer)	DPD
Venango 121-42844	Pleasantville	Mark Resources Corp. CP Unit #9-1	7/24/90	5,958	Queenston (O)	5,799	Medina (S)	60	Complanter pool (Rattlesnake)	Gas

¹NPD, new field discovery; NPD, new pool discovery; DPD, deeper pool discovery.²(D), Devonian; (S), Silurian; (O), Ordovician.³Mcf, thousand cubic feet.

Figure 29. Reported new field and new pool failures in Pennsylvania, 1990.

County and permit no.	Quadrangle	Operator Well no. and lease	Completion date	Total depth (feet)	Formation or group at T.D. ¹	Explor. class ²
Cambria 021-20788	Nanty Glo	Petroleum Development Corp. Bethlehem Steel #1-S	5/22/90	9,091	Helderberg (D)	NPW
Clinton 035-20557	Farrandsville	Eastern States Exploration Co. Commonwealth of Pennsylvania Tract 252 #2	5/22/90	4,920	Lock Haven (D)	NFW
Crawford 039-21963	Edinboro South	Meridian Exploration Corp. Venango Valley #2	7/14/83	4,440	Queenston (O)	NFW
Erie 049-22265	Erie South	DiRienzo, Dominick A. DiRienzo #1	9/ 1/82	2,117	Onondaga (D)	NPW
Lawrence 073-20027	Harlansburg	Steen, Charles L. McMillin, David #1	6/ 5/83	915	Venango (D)	NFW
Somerset 111-20132	Fairhope	Atlantic Richfield Co. Ludy, Noah #1	4/25/84	8,049	Juniata (O)	NFW
Somerset 111-20179	Somerset	CNG Producing Co. Lape, Lester #1	8/19/89	9,015	Helderberg (D)	NPW
Somerset 111-20191	Kingwood	CNG Producing Co. Commonwealth of Pennsylvania Tract 661 #2	1/19/90	8,530	Helderberg (D)	NPW
Tioga 117-20110	Antrim	Willard, Rex E. Davis, Gene #A-5	10/24/81	226	Lock Haven (D)	NFW
Tioga 117-20111	Antrim	Willard, Rex E. Kendrick, S. #A-1	1/ 1/81	1,153	Lock Haven (D)	NFW
Tioga 117-20114	Antrim	Willard, Rex E. Torpy, John #A-1	11/14/81	70	Catskill (D)	NFW
Tioga 117-20133	Antrim	G. C. Young, Inc. Kendrick, S. #A-3	9/10/83	1,500	Lock Haven (D)	NFW
Tioga 117-20139	Marshlands	W. F. Glover State Forest Lands #1	7/29/85	1,617	Lock Haven (D)	NFW

¹(D), Devonian; (O), Ordovician.²NFW, new field wildcat; NPW, new pool wildcat.



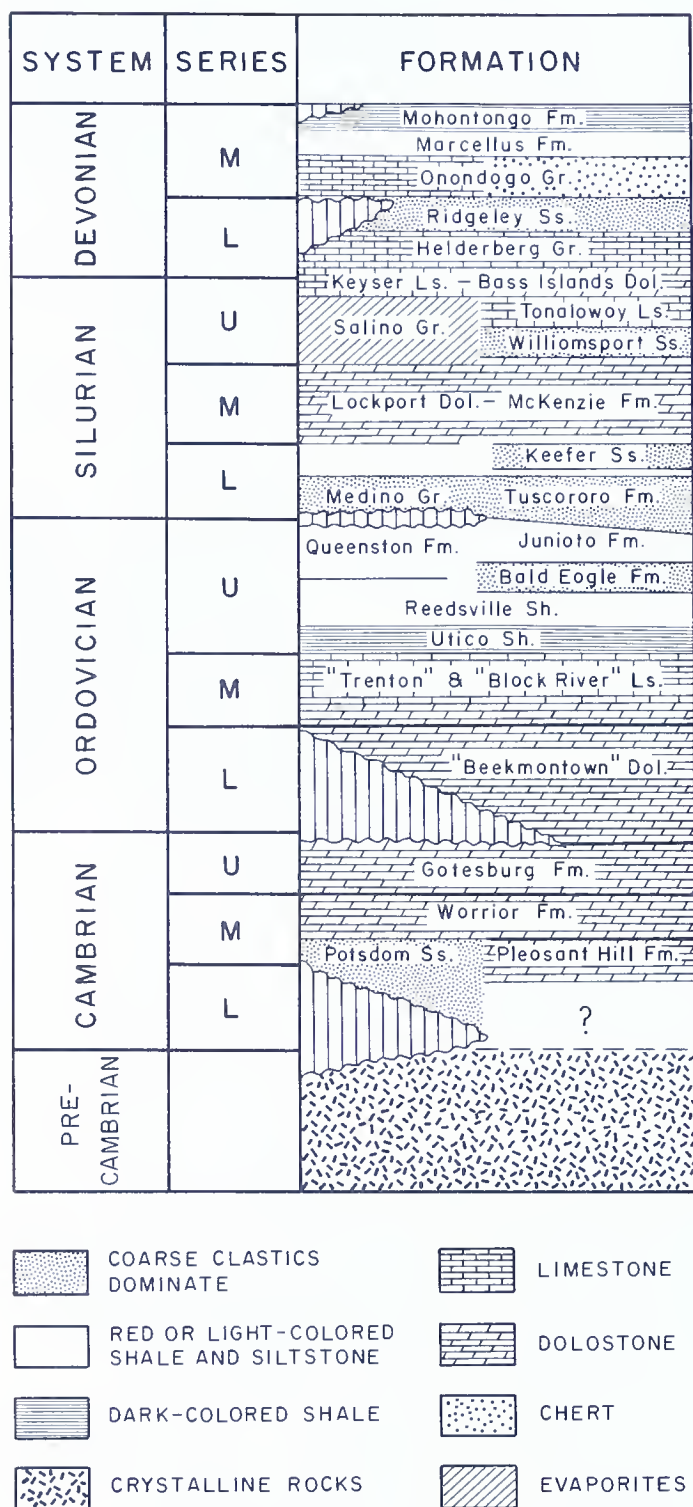


Figure 31. Generalized diagram of the major deep (Tully or deeper) formations occurring in the subsurface of western Pennsylvania.

Onondaga of 2,117 feet (Figure 29). This well, in Summit Township, Erie County, may have been drilled either as a shale well or as a test of the Lower Devonian Oriskany Sandstone. There were no shows reported, and the well was plugged and abandoned.

Drilling for natural gas in the Middle Devonian Huntersville Chert and Lower Devonian Ridgeley Sandstone ("Chert" and "Oriskany" of drillers) has been a time-honored tradition since the discov-

ery of the Tioga field, Tioga County, in 1930. Such drilling once dominated deep activity in Pennsylvania, but since 1978 the Lower Silurian Medina Group has attracted more of the industry's attention than any other deep formation. Unlike wells in the Medina, Huntersville-Ridgeley wells tend to be high-risk ventures because production occurs mainly from structural traps at great depths, in some places exceeding 10,000 feet. The siting of these wells requires a good knowledge of structural geology and the precise application of seismic surveying techniques. Despite the greater expense and higher risk, however, many operators prefer drilling Huntersville-Ridgeley wells because success promises larger reserves and higher yields than those of the Upper Devonian or the Medina.

Reported drilling in the Huntersville and Ridgeley in Pennsylvania in 1990 resulted in 15 new producing wells, 13 of which were in developed fields and pools. Exploration for new reserves in these rocks resulted in two discoveries out of five new field and new pool wildcats (Figure 28). CNG Producing Company discovered the Bullsken field in Bullsken Township, Fayette County, with the drilling of the #1 Kreinbrook well. Drilled to 7,898 feet, the Kreinbrook well was acidized in the Ridgeley Sandstone at 7,743 to 7,753 feet, resulting in an after-treatment open flow of 6,000 Mcf/gpd with a rock pressure of 3,400 psi (pounds per square inch). The Wells Creek pool, a new fault-block reservoir in the Shanksville field, was discovered by CNG Producing Company upon completion of the #1 Skeria well in Somerset Township, Somerset County. This well was drilled to 9,314 feet and was acidized in the Ridgeley Sandstone from 9,117 to 9,162 feet. The after-treatment open flow was gauged at 5,000 Mcf/gpd with a rock pressure of 3,525 psi. The additional three exploratory wells included new pool wildcats in the Boswell and Blue Hole fields, Somerset County, and a new field wildcat in Cambria Township, Cambria County. The two Somerset County wells were drilled by CNG Producing Company, and the Cambria County well was completed as a dry hole by Petroleum Development Corporation (Figure 29).

Two new development wells in the "Bass Islands trend" were reported in Pennsylvania in 1990. One, the ENGX, Inc., #11 Meabon well in Venango Township, Erie County, was completed as a Bass Islands oil well with an after-treatment flush production of 5 bbl from the interval 2,695 to 2,705. This well is in the Lowville pool, which was discovered by drilling of the ENGX #10 Meabon well last year. The second well, the U.S. Energy Development Corporation #5 Lantz in Venango Township, Erie County, was an unsuccessful attempt at recovering gas from the Macedonia pool in the

Carter Hill field. Both of these pools lie within the "Bass Islands trend" that strikes across northwestern Pennsylvania from Chautauqua County, New York.

As mentioned previously, drilling in the Lower Silurian Medina Group has dominated deep-well activities in Pennsylvania since 1978, when enactment of the NGPA made the low-permeability sandstones of the Grimsby and Whirlpool Formations productive from an economic standpoint. Since then more than 5,000 wells have been completed in the Medina in Erie, Crawford, Mercer, Venango, and Warren Counties. During 1990, the industry reported 250 producing Medina wells in Pennsylvania. Most of these were gas wells, but 42 of them, mainly in Mercer County, also had some oil production. Five wells were completed as new field or new pool tests, all of them successful (Figure 28). These included (1) Quaker State Corporation #1 Gilbert, completed from 4,986 to 5,127 feet with an after-treatment open flow of 1,800 Mcfgpd and a pressure of 1,170 psi, the discovery well of the Turkey Track field in Randolph Township, Crawford County; (2) Atlas Resources, Inc., #1 Cupic, completed in the Grimsby Formation from 5,377 to 5,440 feet and in the Whirlpool Sandstone from 5,512 to 5,522 feet with an after-treatment open flow of 1,090 Mcfgpd and a pressure of 1,350 psi, the discovery well of the Lackawannock pool in the shallow Big Bend field, Jefferson Township, Mercer County; (3) Mark Resources Corporation #19-1 CP Unit, completed from 5,652 to 5,777 feet with an after-treatment open flow of 115 Mcfgpd and a pressure of 1,375 psi, the discovery well of the Kaneville pool in the shallow Petroleum Center-Pioneer oil field, Cornplanter Township, Venango County; (4) Quaker State Corporation #1 Goodlett, completed from 5,686 to 5,862 feet with an after-treatment open flow of 1,600 Mcfgpd and a pressure of 520 psi, the discovery well of the Oil Creek pool in the shallow Petroleum Center-Pioneer oil field, Cornplanter Township, Venango County; and (5) Mark Resources Corporation #9-1 CP Unit, completed from 5,735 to 5,799 feet with an after-treatment open flow of 60 Mcfgpd and a pressure of 1,460 psi, the discovery well of the Cornplanter pool in the shallow Rattlesnake field, Cornplanter Township, Venango County.

The only other well of any significance reported during 1990 was one drilled to test the Medina-equivalent Tuscarora Sandstone in Somerset County. The Atlantic Richfield Company #1 Ludy well, a new field wildcat in Northampton Township, was drilled to 8,049 feet in the Upper Ordovician Juniata Formation (Figure 29). It was plugged and abandoned without treatment.

GEOPHYSICAL ACTIVITY IN PENNSYLVANIA

The seismograph is the principal nondrilling exploratory tool used in Pennsylvania for the exploration of oil and gas. Although one or more companies may explore for oil and gas in any given year by using aeromagnetic and gravity sensing devices, these techniques are not considered particularly useful in Pennsylvania. The use of seismic tools is advantageous in that it can give fair to excellent indications of the attitude of rocks (whether they are folded, faulted, tilted, or flat lying) and the depths of potential hydrocarbon reservoirs by measuring the travel time for vibrations generated at the surface to reach the rock. Mechanically generated seismic pulses, especially Vibroseis, and explosive techniques, principally dynamite, are the most widely used in Pennsylvania. Seismic work is typically performed by contracted crews, and the intensity of activity is measured in crew-months.

Seismic activity in Pennsylvania increased slightly in 1990 to 5.0 crew-months from the 4.5 crew-months reported in 1989. Activity reportedly involved about 90 percent dynamite and 10 percent Vibroseis. Oil and gas companies engaged in seismic activity in Pennsylvania in 1990 included CNG Development, Columbia Natural Resources, Texaco, and Belden and Blake. Service contractors involved in geophysical activity were ESI Geophysical, Frontier Oil, Grant-Norpac, and Western Geophysical. These companies ran surveys in Cambria, Clarion, Fayette, Jefferson, and McKean Counties.

ACTIVITIES ON STATE FOREST AND PARK LANDS

Total income received from oil and gas activities on Pennsylvania state forest and park lands during 1990 amounted to \$5,150,425.29. This income was produced from rentals, including bonuses from lease sales, royalties, gas storage rentals, pipeline and compressor station rentals, and seismic surveys. Royalty payments for the year amounted to \$2,513,166.05 for 8,543,248 Mcf of gas. Rentals from gas storage leases totaled \$1,048,531.83, and rentals from all other gas and oil leases totaled \$1,558,918.97. Other income from seismic surveys, pipeline and compressor station rentals, and miscellaneous rentals totaled \$29,750.44.

During the year, 76,940 acres of state forest and park lands were offered for bid for oil and gas exploration in 21 tracts. Of this total, 18 tracts comprising 63,822 acres were successfully bid and placed under lease.

At the end of 1990, a total of 418,377 acres of state forest and park lands were under lease for oil and gas exploration and development. In addition, the state has another 104,247 acres under lease for gas storage located in 11 different gas storage fields.

During 1990, a total of 65 wells were drilled on state forest lands where the state owns the oil, gas, and gas storage rights. Of these, 55 were shallow gas producers, 6 were shallow dry holes, and 4 were deep Oriskany gas storage wells.

PROJECTS IN PROGRESS IN 1990, OIL AND GAS GEOLOGY DIVISION

OIL AND GAS BASE MAPS

The Oil and Gas Geology Division continues to make available to the public a series of 7.5-minute oil and gas base maps. The series covers all of western Pennsylvania's oil and gas fields and the areas of central and eastern Pennsylvania where exploratory drilling has occurred. The series is accessible as ozalid ("blue-line") reproductions of standard U.S. Geological Survey 7.5-minute topographic maps overprinted with well symbols and identifying numbers. The topographic portion of each map is subdued so that the well information stands out, but is still legible on a blue-line reproduction. New well information is added periodically during updating of the map series.

Details for purchasing base maps can be obtained by contacting the Pennsylvania Bureau of Topographic and Geologic Survey, Oil and Gas Geology Division, 400 Waterfront Drive, Pittsburgh, PA 15222-4745, telephone 412-442-4235. When requesting copies of the maps, please provide the 7.5-minute topographic map name of each map desired. Figure 32 shows those parts of Pennsylvania for which base-map coverage is available.

MEASURING AND PREDICTING RESERVOIR HETEROGENEITY IN COMPLEX DEPOSITS—CAMBRIAN AND ORDOVICIAN CARBONATE ROCKS OF WESTERN PENNSYLVANIA

by John A. Harper and
Christopher D. Laughrey

In conjunction with the Appalachian Oil and Natural Gas Research Consortium (AONGRC), which also includes the Ohio Division of Geological Survey, the West Virginia Geological and Economic Survey, and the West Virginia University, the Pennsylvania Geological Survey is under contract to the

U.S. Department of Energy to study reservoir heterogeneity within the tri-state area. The West Virginia portion of the study relates to oil production from the Mississippian "Big Injun sand," whereas Ohio and Pennsylvania are working on the carbonate rocks of the Cambrian and Ordovician. This latter study centers around the Late Cambrian "Rose Run sand" (equivalent to the upper sandy member of the Gatesburg Formation). Oil and gas production from this unit occurs at present in Ohio, and occurred in the recent historic past in Pennsylvania. Production occurs where an Ordovician erosional surface known as the Knox unconformity intersects the multilayered sandy dolostones and dolomitic sandstones of the upper sandy member. The primary objective of this study, which began in October 1990, and is expected to be completed late in 1992, is to characterize the stratigraphy, petrology, structural geology, and depositional environments of the upper sandy member. Investigations of the stratigraphic record from the Upper Ordovician Trenton limestone to the crystalline basement will also be conducted.

GEOCHEMISTRY OF PETROLEUM SOURCE ROCKS IN PENNSYLVANIA

by Christopher D. Laughrey

The Oil and Gas Geology Division continued work on the reconnaissance geochemical study of petroleum source rocks initiated in 1987. In the study, petroleum source rocks in Pennsylvania will be identified and correlated to hydrocarbon reservoirs through determinations of organic content, kerogen types, stable isotope chemistry, and compositions of solvent-extractable hydrocarbons and nonhydrocarbons. Thermal maturities will be determined from optical and physicochemical properties of kerogens and by mathematical modeling. This regional geochemical study should prove useful in determining the patterns of hydrocarbon generation and migration within exploration and development areas in Pennsylvania. Such data are critical to the future development of petroleum reservoirs in the state's mature fields and to the discovery of new fields in unexplored parts of Pennsylvania.

ISOTOPE GEOCHEMISTRY OF NATURAL GASES IN PENNSYLVANIA

by Christopher D. Laughrey and
Fred Baldassare

Natural gas, composed mostly of methane, is ubiquitous in Pennsylvania. It occurs in the reservoir,

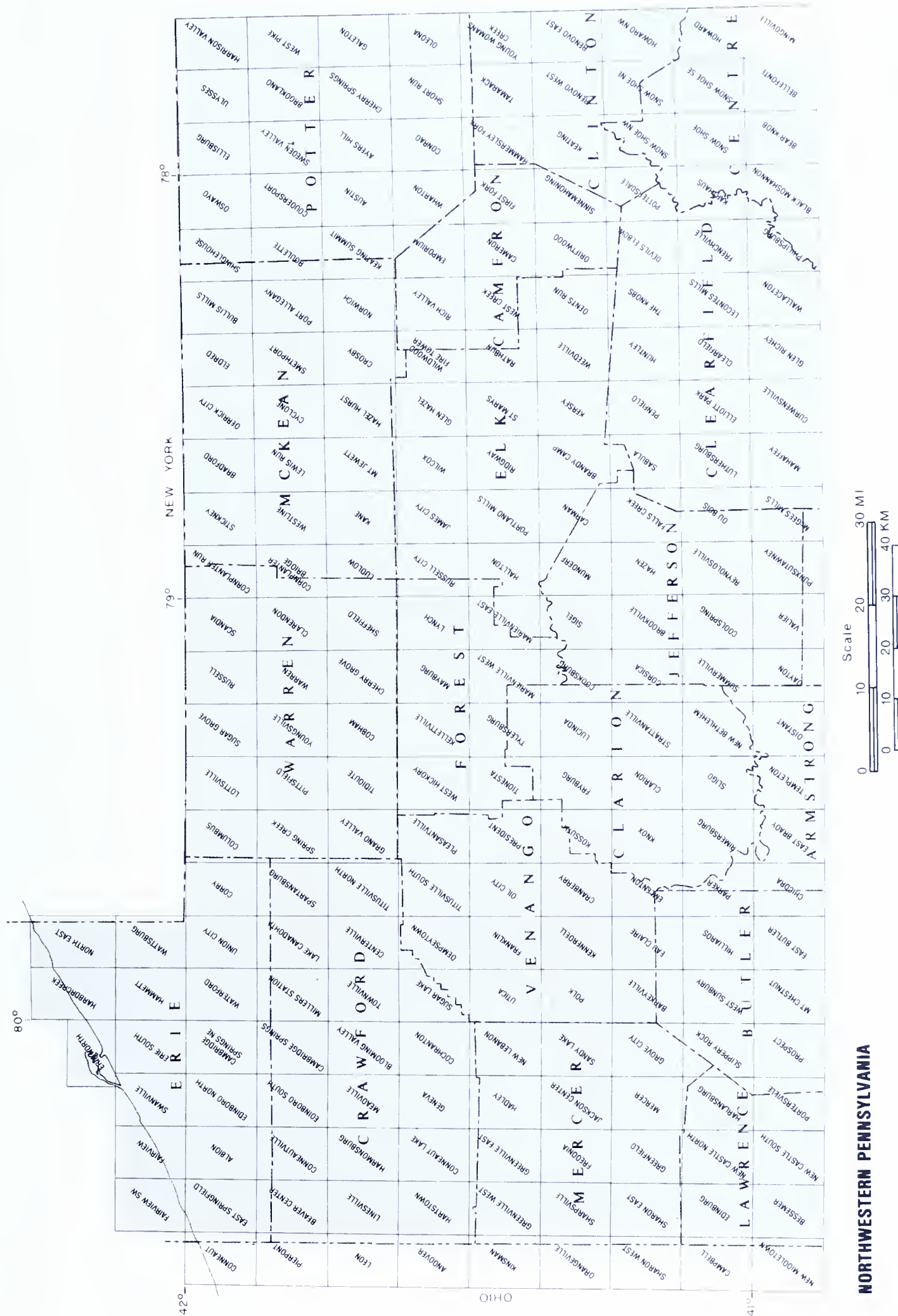


Figure 32. Index maps of available (shaded) 7.5-minute oil and gas base maps.



Figure 32. (Continued).

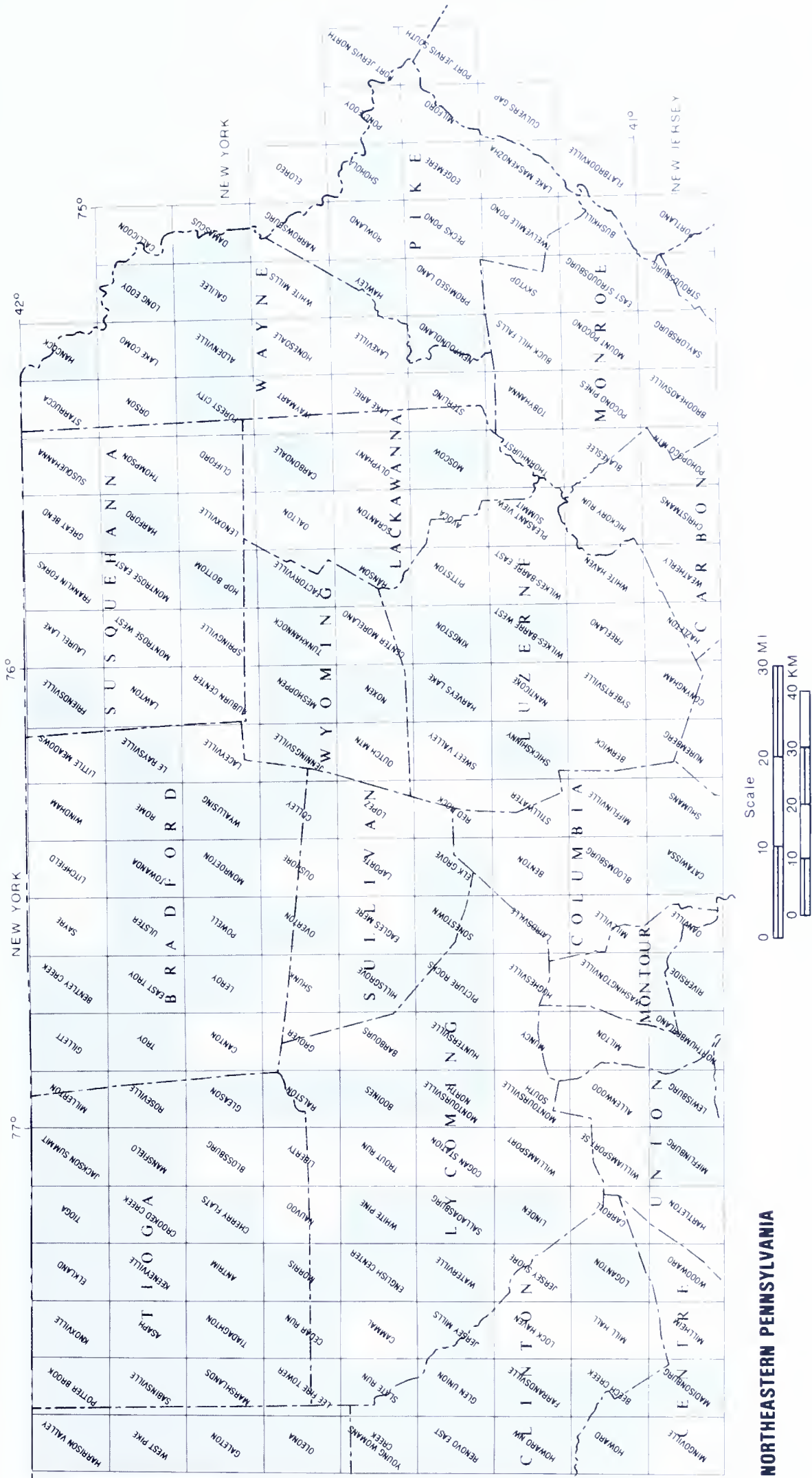


Figure 32. (Continued).

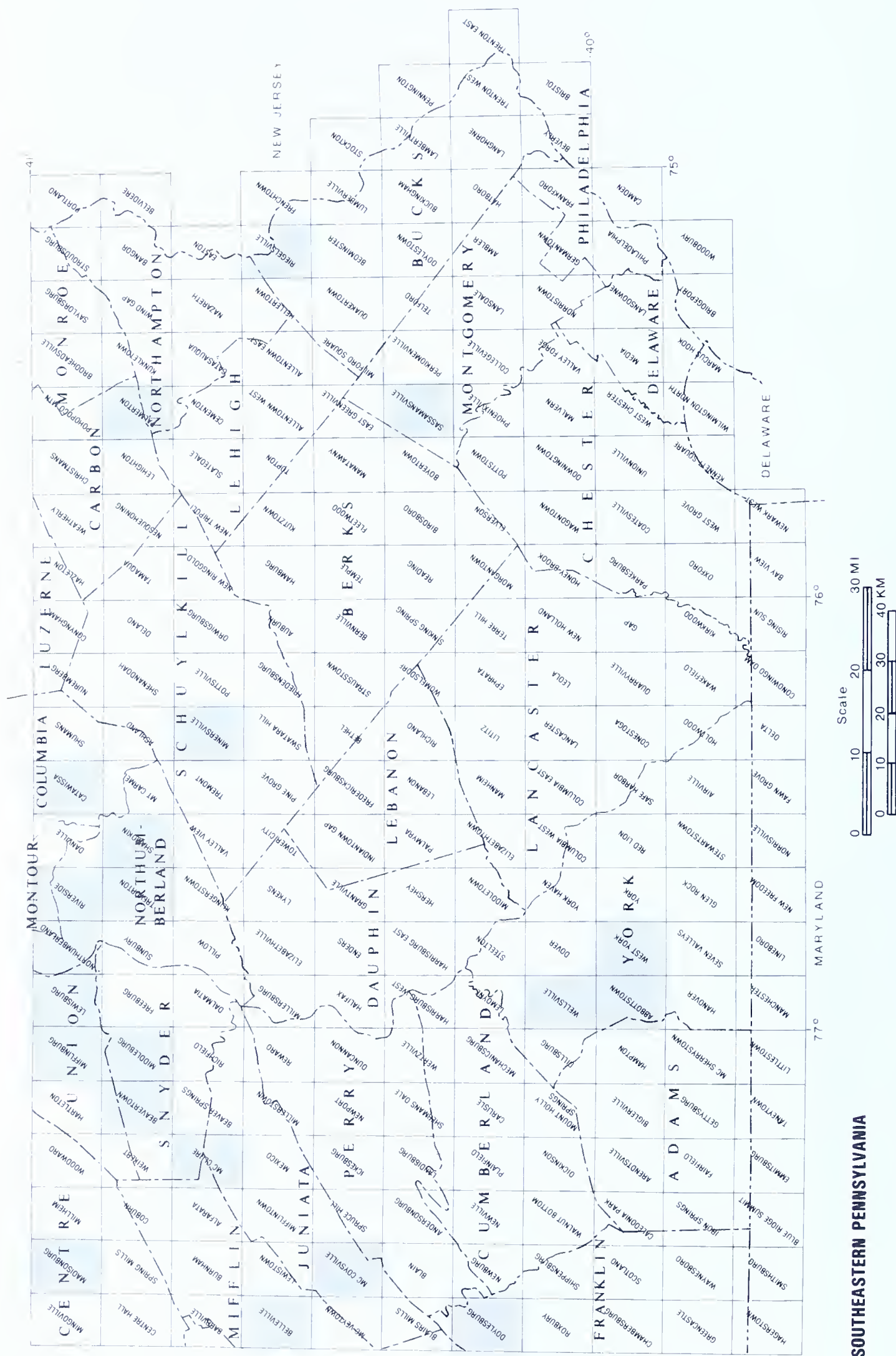


Figure 32. (Continued).

carrier, and source rocks of the state's sedimentary sequences. Gas also occurs in soils, wetlands, and landfills. It is transported across Pennsylvania in pipelines as part of a national gas transportation system. Natural gas is stored in the ground in old, depleted reservoirs. Gas from all of these sources is an energy resource, a mining hazard, a ground-water contaminant, and a community concern. The ability to discriminate between natural gases from all of these sources would benefit workers involved with gas in both environmental and energy-resource strategies.

In 1990, the Pittsburgh Regional Office of the Department of Environmental Resources initiated an investigation of the geochemistry of natural gases in western Pennsylvania. The initial purpose of this study was to assess the feasibility of fingerprinting gases of different origins in the state in order to determine if this method would be useful in investigating environmental hazards. The study has since been expanded in an attempt to genetically characterize the gases using three properties: the relative amounts of hydrocarbon components in the gases, and the stable carbon and stable hydrogen isotope

variations in the methane constituents of the gases. Twenty-six compositional and isotopic analyses of different gases have been obtained for a preliminary determination of the utility of this method for characterizing natural gases in Pennsylvania.

Figures 33 and 34 show 21 of the analyses plotted on interpretive graphs. These graphs show the discrimination between microbial landfill gas, coal-bed methane, oil-associated gases in Devonian-age reservoirs, and nonassociated thermogenic gases in deeper, Silurian-age rocks. The microbial methanes formed through fermentation processes. The coal-bed methane and the associated Devonian gases formed during catagenesis, the main phase of oil generation in the subsurface. Sedimentary organic matter was thermally altered by increasing temperatures and released petroleum in the subsurface. Gases produced from Silurian reservoirs formed through the cracking of oils and kerogens at even higher temperatures.

Further work will be necessary in order to refine these efforts to characterize different gases in Pennsylvania. Current plans are to publish the results of the analyses as soon as possible. Additional

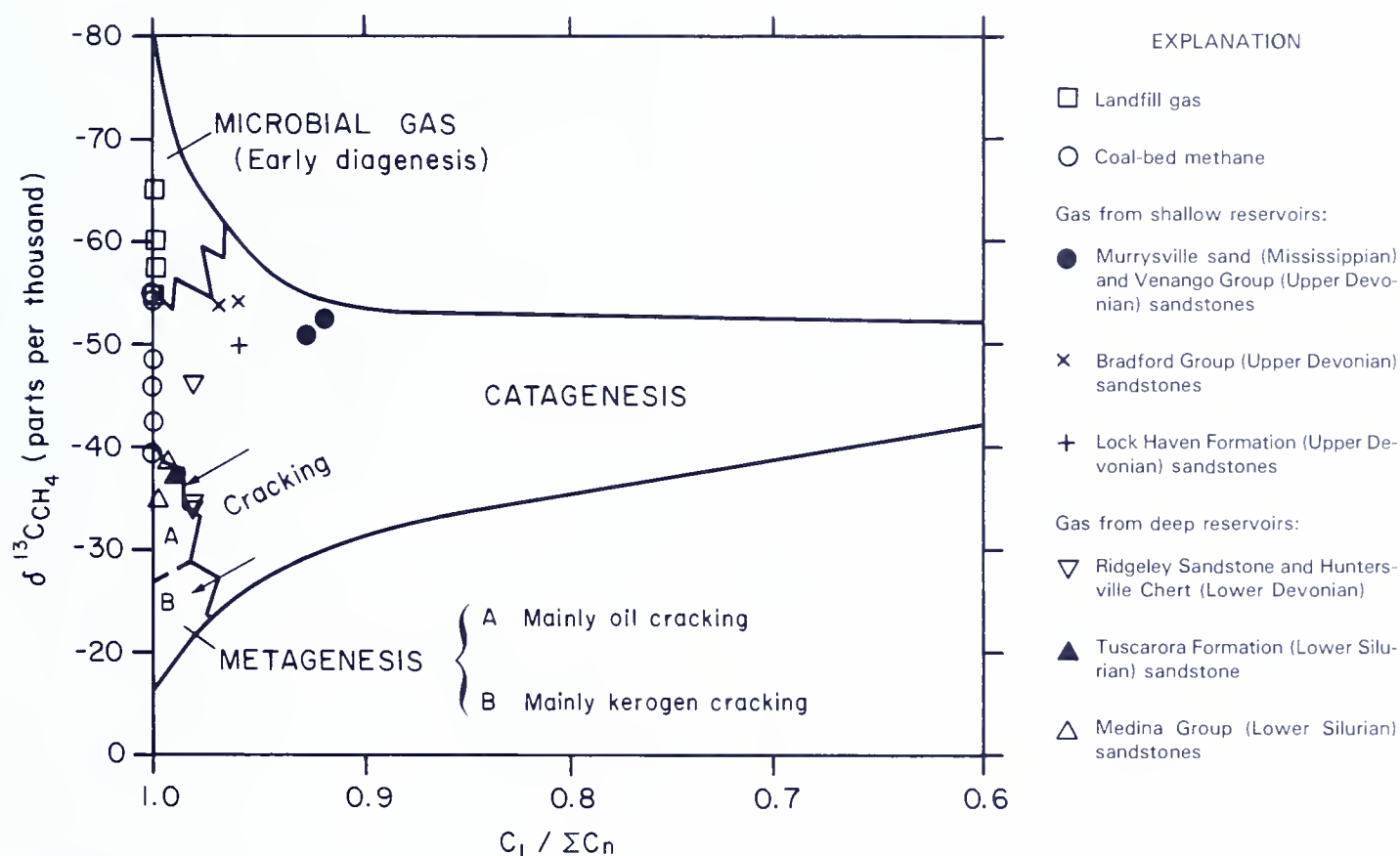


Figure 33. Ratio of methane to total hydrocarbon gases ($C_1 / \Sigma C_n$) plotted against stable carbon isotope variations observed in methane ($\delta^{13}C_{CH_4}$) from various source rocks in Pennsylvania. $\delta^{13}C_{CH_4}$ is the relative difference in the ratio of $^{13}C / ^{12}C$ between the methane sample and an arbitrary standard. Variations in the relative amounts of the abundant ^{12}C and essentially rare ^{13}C in the methanes reflect the kinds of organic matter from which the gases were derived and their thermal history through geologic time.

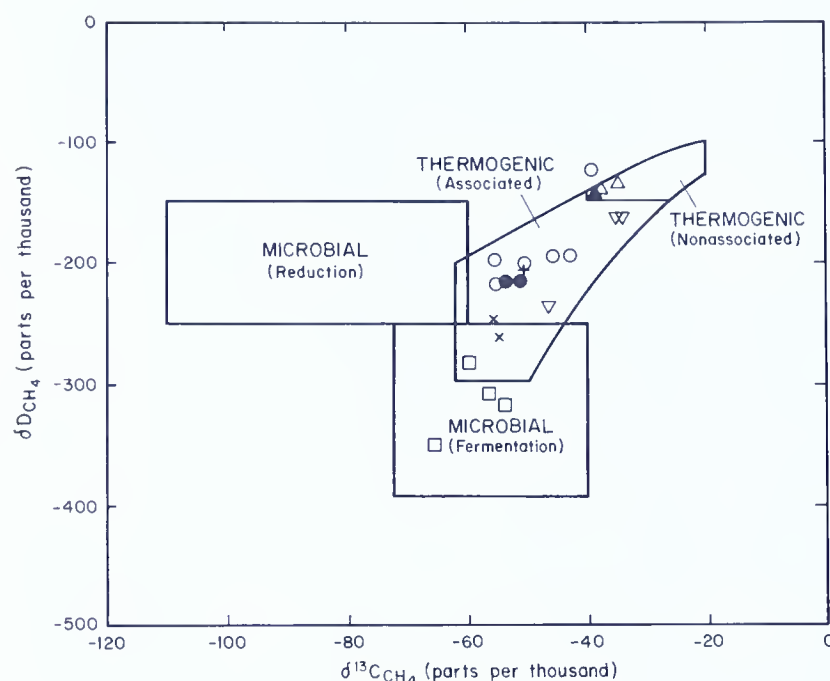


Figure 34. Stable carbon isotope variations observed in methane ($\delta^{13}\text{C}_{\text{CH}_4}$) plotted against isotopic variations of hydrogen and its heavier stable isotope deuterium observed in methane ($\delta\text{D}_{\text{CH}_4}$) from various source rocks in Pennsylvania. $\delta^{13}\text{C}_{\text{CH}_4}$ and $\delta\text{D}_{\text{CH}_4}$ are the relative differences in the ratios of $^{13}\text{C}/^{12}\text{C}$ and D/H , respectively, between the methane sample and an arbitrary standard. Variations in the relative amounts of hydrogen isotopes in the methanes reflect both the biogenic origin of the gases and their thermal maturation history. Symbols used in the graph are the same as those explained in Figure 33.

analyses may establish a reliable and meaningful data base.

PRELIMINARY FEASIBILITY STUDY OF THE COAL-BED METHANE RESOURCE IN PENNSYLVANIA

by Antonette K. Markowski

In 1990, the Oil and Gas Geology Division continued a preliminary study of the feasibility of producing natural gas from Pennsylvanian coals in the western half of the state. This study was initiated in 1987. The general objectives of the study are to identify the potential for coal-bed methane production and, assuming that this potential is high, to (1) identify key areas having high methane content; (2) identify possible trends of high methane content; (3) correlate methane content within various coal seams by rank, thickness, and burial depth; and (4) assess the geologic implications of coal-bed methane as a supplemental and/or alternative energy source. Only minor work has been done on this little-known but valuable natural resource in Pennsylvania. However, because of the growing interest nationwide in the degasification of deep-lying coals having high methane content, this project should provide useful information on coal-bed methane on a regional basis. The final report should prove interesting to the coal-mining industry, the oil and gas industry, academic and industrial customers using cogeneration power plants, and the general public.

GEOLOGIC EVALUATION OF CRITICAL PRODUCTION PARAMETERS FOR COAL-BED METHANE IN PENNSYLVANIA

by Antonette K. Markowski

The Pennsylvania Geological Survey and the West Virginia Geological and Economic Survey are conducting a joint preliminary investigation of coal-bed methane resources in the Northern Appalachian coal basin. The project is funded by the Gas Research Institute and is coordinated by the Texas Bureau of Economic Geology. The focus of the study is an elliptical area in the deepest part of the basin, the Pennsylvania portion of which extends from Greene County northeastward to central Indiana County. The main objective of this study is to map the Pennsylvanian and Permian coal-bearing intervals and coal seams from the Dunkard Group to the deeper coals of the Allegheny and Pottsville Groups. Another objective is to address the factors that influence coal-bed methane production and development in the basin. The distribution and continuity of southwestern Pennsylvania coal-bearing groups and their coals will be identified, and geologic cross sections and maps showing the extent of each group will be drawn. Also, the sedimentological controls on the occurrence of coal-bed methane, the structures that may form conventional traps and enhance coal-bed permeability, fracture systems, known coal-bed methane pools and production, and general resource estimates will be discussed. The report will be useful to the oil and gas

industry, coal-mining industry, consultants, utility companies, and the interested public. It is intended to encourage further exploration and commercial use of coal-bed methane in the target area.

OPEN-FILE REPORTS AND OTHER DATA AVAILABLE

The following reports and other data are available on open file at the Pennsylvania Bureau of Topographic and Geologic Survey, Oil and Gas Geology Division, 400 Waterfront Drive, Pittsburgh, PA 15222-4745.

*Open-file
report no.*

- 1 *Surface to Middle Devonian (Onondagan) Stratigraphy, Part I (STOMDES)*, 1972, by D. R. Kelley and W. R. Wagner, 15 p., 8 cross sections, vertical scale 1 inch = 100 feet.
- 2 *Deep Sand Exploration and Gas Developments in Pennsylvania*, 1989, by L. J. Balogh, 2 map sheets, scale 1:250,000.
- 3 *Salina or Equivalent and Deeper Penetrations of Pennsylvania*, 1973, by D. R. Kelley and L. J. Balogh, 1 map, scale 1:500,000 (last updated in 1979).
- 4 *Tully and Deeper Formations, Brine Analysis of Pennsylvania*, 1973, by D. R. Kelley and others, 1 chart and map, scale 1:500,000.
- 5 *Stratigraphic Framework of the Greater Pittsburgh Area, Parts I and II*, 1972, by W. R. Wagner and W. S. Lytle, 20 p., 9 sections in 13 sheets.
- 6 *Active Gas Storage Areas Map of Pennsylvania*, 1981, by L. J. Balogh, 1 map, scale 1:500,000 (updated as needed).
- 7 *Subsurface Rock Correlation Diagram, Allegheny Plateau, Pennsylvania*, 1979, by J. A. Harper, 1 sheet.

There are also over 110,000 drillers' records and logs, along with approximately 9,400 geophysical logs, on open file at the Pittsburgh office of the Pennsylvania Geological Survey. Approximately 44,000 of the 110,000 records on file consist of well-data cards compiled by the U.S. Geological Survey and the Pennsylvania Geological Survey between 1900 and 1970 as the bases for topographic-map quadrangle reports. In addition, the Survey has a

sample library containing drill cuttings from approximately 1,200 wells and a core storage library containing cores from 48 wells, including the 5 wells cored under the Eastern Gas Shales Program of the U.S. Department of Energy. All cuttings and cores are available for inspection and study.

REVIEW OF THE 1980'S AND PROSPECTIVE TRENDS FOR THE 1990'S

by John A. Harper

It has been a practice during the last three decades to include a "ten-year review and forecast" chapter in *Oil and Gas Developments in Pennsylvania* in the year that begins a decade. As in the past, this special portion of the annual report contains a summary of trends in the oil and gas industry during the past decade in subsurface geology and drilling and production statistics, and a discussion of the politics and economics that drive the trends. In addition, there is an attempt to take this information and weave a believable future, so as to draw the attention of industry to undeveloped or underdeveloped reservoirs and to particular areas of the Commonwealth in the hopes that such attention will eventually result in drilling and production during the upcoming decade. This attempt is not meant as a recommendation of sites, nor is it a prognostication of political and economic trends.

THE 1980'S IN REVIEW

The decade of the 1980's was a tumultuous one for the oil and gas industry as well as for the hydrocarbon consumer. Increases in oil and gas prices in the late 1970's, spurred by the OPEC cartel in 1973 and the NGPA in 1978, created a whole new outlook for oil and gas companies and their employees. In January 1981, just after taking office, President Reagan signed legislation deregulating oil prices; in contrast, NGPA was designed to gradually deregulate natural gas prices throughout the 1980's. This release from most artificial price restrictions created a flurry of drilling activity and an increase in exploration, resource acquisitions, hirings, and employee mobility. New companies formed overnight as numerous people with "black-gold fever" got financial backing, hired recently graduated geologists and engineers, and began accumulating pro-

spective leases. The mood of the industry in general was optimistic. At the same time, the public's perception of the industry continued in the same vein as that of the 1970's; namely, that oil and gas companies were greedy and insensitive to consumers and the environment. Only a few companies attempted to dispel this perception.

As the drilling increased, so did production, until there was more supply than demand. At that point, the "boom" began to subside as the market took over, prices plummeted, and companies saw their financial backing abate. Thus, the "boom" became a "bust" by the middle of the decade. In a total reversal of fortunes, companies began laying off employees, selling their holdings, moving out of marginal areas, going out of business, and doing anything else they could to reduce costs. Hostile takeovers, made popular by Texan T. Boone Pickens, occurred as some companies attempted to increase their value and their hydrocarbon resources by buying their undervalued competition. By the end of the decade, the industry was once again as lean as it was in the early 1970's.

Industrial whiplash resulting from the "boom" and "bust" cycle was as evident in Pennsylvania as it was in the rest of the nation. In the early 1980's, companies were created by diverse individuals who had little or no experience but money to invest; landowners were offered incredible leases, some as strange as 6-month leases on quarter-acre lots, leading other landowners to demand higher lease fees and larger royalties. The oil industry, which had been stagnant for decades in Pennsylvania, came alive as thousands of wells were drilled in backyards and wooded lots of the Allegheny National Forest. More than 27,900 wells in all were reported during the 1980's,¹ more than all of the wells reported in the previous 25 years! (Figure 35 shows the totals for all wells reported in the 1980's, except miscellaneous wells.) Although no reliable figures exist yet to substantiate it, it appears that most of these wells were drilled before 1986. By that time, Pennsylvania's industry was reeling from the effects of the "bust." The number of permits issued for new drilling, which had been as high as 11,700 in 1984, fell to 2,500 in 1986. Prices for Penn Grade crude oil fell from an average of \$37.42/bbl in 1980 to an average of \$15.66/bbl in 1986. The average price for natural gas rose from \$1.50/Btu (British thermal unit) in 1980 to \$3.25/Btu in 1984, then fell back to the \$2.00 range by the end of the decade. By 1989, only two or three companies were still drill-

ing new wells in the oil fields of northern Pennsylvania, and only the natural gas industry seemed to have any life left in it.

Adding to the market downturn, new regulatory efforts at both the state and federal levels also helped to decrease interest in Pennsylvania's oil and gas resources. In July 1982, the Pennsylvania Department of Environmental Resources created the Bureau of Oil and Gas Management to implement the regulatory processes instituted by laws passed in the 1950's and 1960's. In November 1984, a new oil and gas act (Act 223) that increased the Commonwealth's responsibilities for permitting and regulating the oil and gas industry in order to protect the environment and the health and welfare of the citizens was signed into law. This law has brought Pennsylvania into the twentieth century in terms of environmental protection and requirements for reporting drilling and production. Opposition to the law by industry is understandable; for 125 years oil and gas well drillers and producers have had a veritable free hand in Pennsylvania. The new law, which required either bonding or plugging of all wells, plus strict enforcement of regulations protecting wetlands, potable water supplies, and so forth, is seen by some in the industry as a bureaucratic intrusion into their rights to make a living and by others as a nuisance requiring more paperwork and more money to do what they had already been doing for years. One outspoken oilman, who refuses to abide by the new law, claims that compliance will put him out of business. In contrast, environmentally minded individuals, both inside and outside the oil industry, hailed the new law as a major change in the right direction.

One of the problems of the 1980's was that the federal government did not address the issue of a realistic national energy strategy. To the complex questions of production, consumption, conservation, pricing, and importation were given the simplistic answers of "produce more" and "consume more." There were no incentives to conserve energy, protection of critical environmental areas was largely ignored, and funding for alternative energy research, initiated during the "energy crisis" years of the 1970's, dried up. With falling energy costs, Americans returned to their pre-1973 habit of buying energy-wasting cars and appliances.

Oil Developments

Figure 36 shows the areas of Pennsylvania that were most active in oil well drilling during the 1980's. These areas accounted for most of the 134 percent increase in drilling over that of the 1970's.

¹The number of wells actually drilled may eventually exceed 30,000 when all of the records have been collected and tallied.

Figure 35. *Reported new wells and old wells drilled deeper in Pennsylvania, 1980-89*

<i>County</i>	<i>Oil wells</i>	<i>Gas wells</i>	<i>Combination oil and gas wells</i>	<i>Dry wells</i>	<i>Total wells</i>	<i>Percent success rate</i>
Allegheny	1	32	2	9	44	80
Armstrong	3	893	0	8	904	99
Beaver	62	4	0	15	81	81
Bedford	0	0	0	3	3	0
Bradford	1	0	0	0	1	100
Bucks	0	0	0	1	1	0
Butler	56	27	4	21	108	81
Cambria	0	311	0	18	329	95
Cameron	0	3	0	7	10	30
Centre	0	261	0	25	286	91
Clarion	114	306	22	18	460	96
Clearfield	0	1,243	0	45	1,288	97
Clinton	0	107	0	34	141	76
Crawford	39	1,469	55	43	1,606	97
Elk	469	161	5	36	671	95
Erie	3	2,261	20	41	2,325	98
Fayette	0	104	1	24	129	81
Forest	1,484	69	43	25	1,621	98
Greene	0	122	2	13	137	91
Indiana	0	2,865	0	35	2,900	99
Jefferson	5	745	3	20	773	97
Juniata	0	0	0	1	1	0
Lawrence	0	2	0	1	3	67
Lycoming	0	1	0	3	4	25
McKean	1,022	92	74	41	1,229	97
Mercer	12	390	37	20	459	96
Mifflin	0	0	0	2	2	0
Montgomery	0	0	0	1	1	0
Northumberland	0	0	0	1	1	0
Potter	77	28	6	21	132	84
Somerset	0	50	0	29	79	63
Sullivan	0	0	0	3	3	0
Tioga	4	2	0	10	16	38
Venango	5,205	611	4	142	5,962	98
Warren	3,658	619	71	65	4,413	99
Washington	16	42	2	22	82	73
Westmoreland	3	847	7	39	896	96
TOTAL	12,234	13,667	358	842	27,101	97

Figure 37, which shows the average number of oil, shallow gas, and deep gas wells drilled annually during the last four decades, gives some indication of this increase.

The number of wells drilled increased sharply during the first half of the decade, then fell off over the latter half. The majority of new wells were situated in well-known areas and consisted mostly of in-fill and marginal drilling. Some new reserves were found by moving outward from established fields,

but in general, there were almost no outstanding discoveries during the decade.

Over 97 percent of the oil produced in Pennsylvania during the 1980's was from shallow reservoirs (Figure 38), particularly the Upper Devonian Venango and Bradford Groups. Some subsidiary production from Pennsylvanian and Mississippian reservoirs, and from the Upper Devonian Elk Group and Lock Haven Formation, occurred but was of minor importance to the overall total. Of more im-

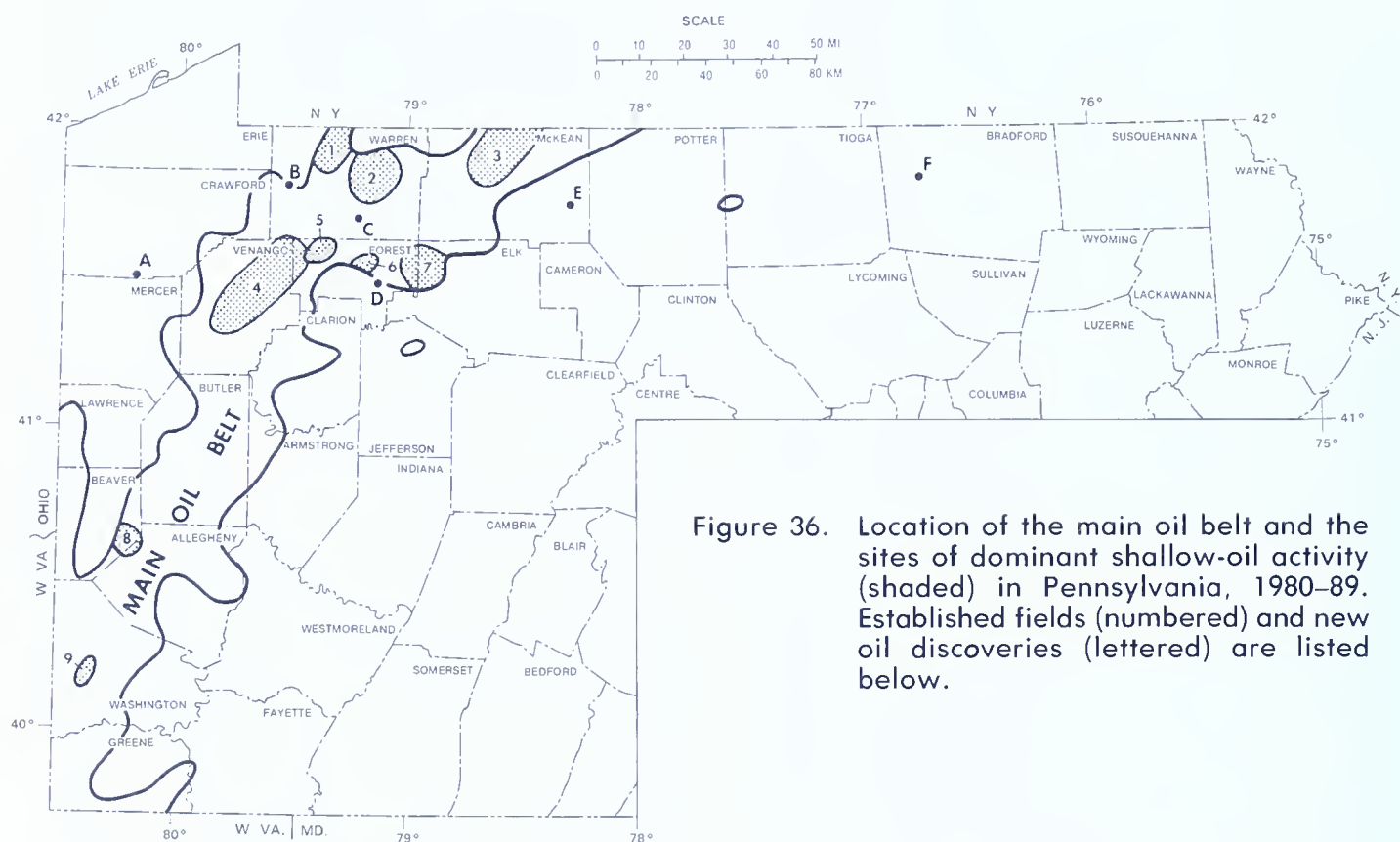


Figure 36. Location of the main oil belt and the sites of dominant shallow-oil activity (shaded) in Pennsylvania, 1980-89. Established fields (numbered) and new oil discoveries (lettered) are listed below.

LIST OF ESTABLISHED OIL FIELDS OR POOLS (NUMBERED) AND NEW OIL DISCOVERIES (LETTERED)

NO. OR LETTER	FIELD OR POOL	RESERVOIR	NO. OR LETTER	FIELD OR POOL	RESERVOIR
1	Sugar Grave and Youngsville fields	Bradford (Glade sand)	9	Washington-Taylorstown field	Venanga (Garden sand)
2	Warren and Clarendan fields	Bradford (Glade and Clarendan sands)	A	Sunal paal	Venanga (Venanga Third sand)
3	Bradford field	Bradford (Bradford Third sand)	B	Middle Branch paal	Bradford (Queen sand)
4	Venanga County area	Venanga (Venanga sands)	C	Rams Harn paal	Bradford (Glade and Clarendan sands)
5	East Hickory and Whig Hill fields	Bradford (Queen sand)	D	Jeep paal	Bradford (Balltown and Caaper sands)
6	Balltown-Truemans field	Bradford (Balltown sands)	E	Tramraad paal	Bradford (Kane sand)
7	Kane field	Bradford (Kane sand)	F	Brace Creek field	Lack Haven (unnamed sand)
8	Dunn paal	Venanga (Fifty-Foot sand)			

Figure 37. Average number of oil and gas wells reported in Pennsylvania.

Type of well	Average number of wells per year			
	1950's	1960's	1970's	1980's
Oil	28	246	585	1,224
Shallow gas	238	180	524	865
Deep gas	139	98	51	502

portance was the substantial increase in oil production from deep horizons. Even though deep oil accounted for less than 3 percent of the total, this was still an increase over that of the 1970's. The Lower

Silurian Medina Group was the main supplier of this commodity, formerly classified as Corning Grade crude oil. Subsidiary production from Middle Devonian Onondaga Limestone and Lower Devonian through Upper Silurian carbonate rocks in northwestern Pennsylvania added to the deep total.

The lone new field discovery in the 1980's occurred when Mark Resources Corporation found oil in Bradford County in 1987 while drilling for natural gas (Figure 36). The company had staked a test of the Lower Devonian Ridgeley Sandstone near the town of Troy in northeastern Pennsylvania. The Ridgeley proved to be unproductive, but a show of oil between 774 and 785 feet in the Upper Devonian Lock Haven Formation was interesting enough

Figure 38. *Crude oil and natural gas production in Pennsylvania in the 1980's*

	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	TOTAL
<i>Crude oil production</i> ¹	2,940	3,729	4,282	4,491	4,825	4,851	3,783	3,302	2,807	2,602	37,612
Shallow	2,867	3,665	4,211	4,402	4,704	4,688	3,619	3,167	2,703	2,499	36,525
Deep	73	64	71	89	121	163	164	135	104	103	1,087
<i>Natural gas production</i> ²	97,439	122,454	121,111	118,372	166,342	150,541	159,889	163,318	167,089	191,774	1,458,329
Shallow	82,570	101,173	95,332	90,449	133,258	112,739	124,070	122,944	130,322	145,251	1,138,108
Deep	14,869	21,281	25,779	27,923	33,084	37,802	35,819	40,374	36,767	46,523	320,221

¹In thousands of barrels.²In millions of cubic feet.

to cause the company to plug the well back and test. After stimulation, the well flowed enough oil to be commercial, and by the end of 1988, it produced a total of 318 bbl (at an average of just under 0.5 bopd). The well was inactive in 1989, but the company believes that there is yet potential in that area. The well is significant from several standpoints. First, it is the first new oil field discovery in Pennsylvania in more than 20 years. It is also the most remote oil production in the Commonwealth. Establishment of production of any kind this far northeast will hopefully stimulate the industry to begin the search for new reservoirs throughout north-central and northeastern Pennsylvania.

Enhanced oil recovery went into a general decline in Pennsylvania in the late 1980's. During the first half of the decade, the number of secondary recovery wells drilled in the Commonwealth increased along with the number of production wells. Numerous gas-injection wells were drilled in Venango County, western Forest County, and southwestern Warren County, where the Venango Group provides most of the oil production. In that area, the coarse sandstones and conglomerates of the Venango Group are more amenable to gasflooding than waterflooding. In contrast, the finer grained sandstones of the Bradford Group are almost ideal for waterflooding, and the majority of waterflood wells were drilled in the Bradford Group oil district of Warren County, eastern Forest County, western Elk County, and McKean County. There was even an attempt to waterflood the finer grained Venango Group sandstones in Washington County. By the end of the decade, however, only Pennzoil Company was still drilling water-injection wells for their waterflood projects in the Kane field, Elk County. Pennzoil Company, in conjunction with several partners, also operated the only three tertiary oil recovery projects in the Commonwealth during the 1980's. These projects, begun in the Bradford field in McKean County in the late 1970's, were discontinued during the early to middle part of the decade.

Two of the projects utilized a microemulsion-polymer flood and the third, under the auspices of the U.S. Department of Energy, was an experimental micellar-polymer flood. In their final report to the U.S. Department of Energy on this project (Ondrusek and Paynter, 1982), Pennzoil indicated several problems due to permeability variations in the rock. Control of mobility could not be maintained because the chemicals displaced oil only in the higher permeability sandstones, leaving the remainder of the reservoir virtually unaffected. At the termination of the project, only 5.2 percent of the oil originally estimated to be in place had been produced. Although this project was not performing up to standards, Pennzoil had been optimistically evaluating other areas of the Commonwealth for future projects. Any plans seem to have been shelved, however, awaiting a better economic climate.

Gas Developments

From 1980 to 1989, Pennsylvania's natural gas industry reported completion of 13,667 gas wells in the Commonwealth, or an average of 1,367 wells per year. This is in contrast to the average of 575 gas wells reported annually in the 1970's (Figure 37).

Figure 7 shows the changes in natural gas production, consumption, and reserves in Pennsylvania during the period 1946 to 1990. Figure 38 shows the breakdown of production by deep and shallow reservoirs for the 1980's. During the decade, production increased by 98 percent, from 97 to 192 Bcf/yr (billion cubic feet per year). Reserves, however, decreased 15 percent during this period, from 2,316 to 1,968 Bcf, and the largest single annual decrease occurred in 1982 (down 20 percent from 1981) (Figure 39). Yet, whereas the estimated total proved recoverable reserves for the 1970's averaged about 1,673 Bcf/yr, in the 1980's this average increased to 2,051 Bcf/yr.

As shown in Figure 39, the amount of natural gas in storage during the 1980's fluctuated, and it ulti-

Figure 39. *Crude oil and natural gas reserves in Pennsylvania in the 1980's.*

	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989
Crude oil reserves ¹	50,559	50,946	49,764	71,010	57,859	53,007	49,223	45,921	43,114	41,563
Natural gas reserves ²	2,316	2,481	1,997	1,855	1,881	1,979	2,054	2,013	1,970	1,968
Gas in underground storage ²	557	597	631	581	621	537	586	586	598	504

¹In thousands of barrels.

²In billions of cubic feet.

mately decreased by 9.5 percent over the course of the decade. Storage reservoirs are scattered over western and north-central Pennsylvania (Figure 8); they are also geologically diverse, ranging from Lower Pennsylvanian sandstones of the Allegheny Group to the Lower Silurian Medina Group sandstones. The majority of storage reservoirs occur in the Upper Devonian Venango and Bradford Group sandstones and the Lower Devonian Ridgeley Sandstone.

The NGPA of 1978 was, perhaps, the single most influential reason for the increase in both natural gas production and drilling. By allowing operators to obtain increasingly higher prices for their gas, the NGPA significantly increased the incentive to drill (at least until supplies far outstripped demand). The 1980's went on record as one of the warmest decades, and the gas that was produced in Pennsylvania, as well as gas produced elsewhere and transported to Pennsylvania via the interstate pipeline system, created a large surplus (the widely reported "gas bubble"). As prices fell, so did the amount of drilling, and by the end of the decade, the number of new wells reported annually approached the low levels recorded in the early 1970's.

The Pennsylvania Geological Survey traditionally separates gas well drilling and production into the categories of deep and shallow reservoirs; therefore, the discussion of reservoirs below is also separated. (Oil reservoirs are also deep and shallow; but because 97 percent of Pennsylvania's oil comes from shallow reservoirs, oil activity is discussed in a single section.)

Shallow Gas

Shallow gas wells accounted for 8,888, or 33 percent, of the 27,101 well records reported between January 1, 1980, and December 31, 1989 (Figure 35). The average number of wells per year increased by 70 percent over the average for the 1970's (Figure 37). Unlike the 1970's, in which the number of shal-

low gas wells reported annually increased steadily throughout the decade, the number of reported wells had a bimodal distribution in the 1980's (Figure 18). Reported drilling increased from 803 to 1,079 wells between 1980 and 1982, declined to 585 in 1983, then increased a second time to a high of 1,276 wells in 1985. The first peak probably was due to modest price increases for natural gas allowed under Sections 102 and 103 of the NGPA. The second peak undoubtedly was due to designation of the reservoir rocks in large portions of western Pennsylvania as "tight" formations under Section 107 of NGPA (see p. 5). Section 107 allowed operators to request almost twice as much money for their gas as they would have received under Sections 102 and 103.

The increase in drilling also had the effect of increasing production. However, analysis of the two variables shows that whereas drilling had a bimodal distribution, shallow-natural-gas production increased almost steadily from 83 Bcf in 1980 to 145 Bcf in 1989 (Figure 38). This constituted a 76 percent increase by the end of the decade.

Figure 40 shows the areas of most intense shallow-gas-well drilling activity during the 1980's. Most of the drilling was centered in or near the established fields of Indiana, Clearfield, Armstrong, Westmoreland, and Jefferson Counties. This indicates that Pennsylvania's shallow-gas-well drillers and their investors tended to be very conservative, preferring to drill in tried-and-true areas rather than attempting to discover new reserves. However, as Figure 40 indicates, there was a considerable amount of eastward extension of the established area into Clearfield and Cambria Counties. In addition, the discovery of the Council Run field in north-central Centre County in 1982 was instrumental in focusing attention on the potential of the Upper Devonian sandstones in the area of Centre and Clinton Counties.

Although natural gas can be found in almost all shallow formations, from the Pennsylvanian-age

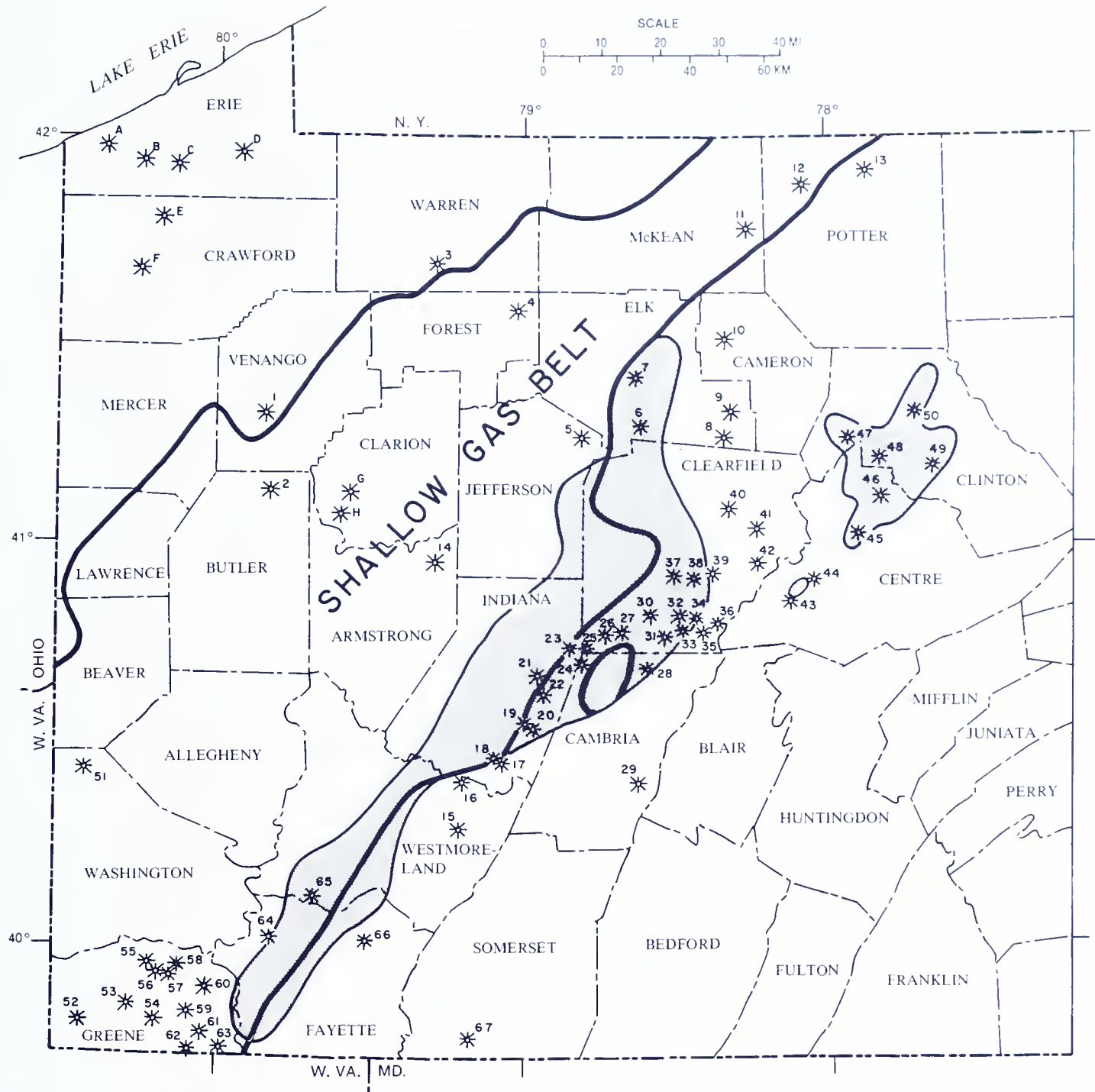


Figure 40. Location of the shallow-gas belt and the sites of dominant shallow-gas activity (shaded) in Pennsylvania, 1980-89. Conventional and unconventional gas discoveries are listed below.

LIST OF CONVENTIONAL (NUMBERED) AND UNCONVENTIONAL (LETTERED) GAS DISCOVERIES

NO. OR LETTER	FIELD OR POOL	RESERVOIR	NO. OR LETTER	FIELD OR POOL	RESERVOIR
1	Pine Hill Run pool	Bradford	13	Wolf Hallaw paal	Lack Haven
2	Seatan Creek paal	Bradford	14	Eddyville paal	Elk
3	Altham Eddy paal	Bradford	15	Wilpen field	Bradford
4	Blue Jay Spring paal	Bradford	16	West Balivar field	Elk
5	Toby Creek field	Brodford	17	Germany field	Brodford
6	Challenge paal	Bradford	18	West Wheatfield paal	Elk
7	Daguscahanda paal	Elk	19	Rabinsan paal	Bradford
8	Barr Hallaw paal	Bradford	20	Littletown paal	Bradford
9	Sinnemahaning paal	Brodford	21	Buck Run paal	Bradford
10	Elk Fork pool	Bradford	22	Mentcle paal	Bradford
11	Allegheny Partage pool	Bradford	23	Bawdertawn paal	Shenango
12	Herring Hallaw paal	Bradford	24	Shozen pool	Brodford

LIST OF CONVENTIONAL (NUMBERED) AND UNCONVENTIONAL (LETTERED) GAS DISCOVERIES (*Continued*)

NO. OR LETTER	FIELD OR POOL	RESERVOIR	NO. OR LETTER	FIELD OR POOL	RESERVOIR
25	Buterbough pool	Brodford/Elk	50	Wertz Hollow field	Lock Hoven
26	Bircholl pool	Bradford	51	Strip Mine pool	Brollier
27	Ferguson field	Venongo/Brodford	52	Stoggers pool	Brollier
28	St. Lawrence field	Bradford	53	Huffmon pool	Brollier
29	Dutchtown field	Scherr	54	Potterson pool	Brollier
30	Berwinsdole pool	Mississippion	55	Wolkers Run pool	Brollier
31	Diehl town field	Brodford	56	Beasley pool	Brollier
32	Lock pool	Elk	57	Ruff Creek pool	Brollier
33	Glen Hope field	Bradford	58	Croynes Run pool	Brollier
34	Modero field	Brodford	59	Woods Run pool	Brollier
35	Romey field	Brodford	60	Khedive pool	Brollier
36	Porsonville field	Lock Hoven	61	Headley pool	Burgoon
37	Bridgeport pool	Brodford	62	Dooley Run pool	Brollier
38	Sonbourn pool	Venongo/Brodford	63	Donley Run pool	Venongo
39	Turkey Hill pool	Venongo/Brodford	64	Little Redstone pool	Venongo/Brollier
40	Stump Lick field	Brodford	65	Morrow Hollow pool	Brodford
41	Kylertown field	Brodford/Elk	66	Rosler Run field	Venongo
42	Pordee pool	Lock Hoven	67	Wolf Rock pool	Scherr
43	Sondy Ridge field	Lock Hoven	A	Ploteo pool	Devonion shale
44	Rush pool	Brollier/Horrell	B	Elk Volley pool	Devonion shale
45	Frost pool	Lock Hoven	C	Dorrows Creek pool	Devonion shale
46	Council Run field	Lock Hoven	D	Troyer pool	Devonion shale
47	Moccosin pool	Lock Hoven	E	Allionce pool	Devonion shale
48	Podunk field	Lock Hoven	F	Humphreys pool	Devonion shale
49	Sloughing Ground field	Lock Hoven	G	Minich pool	Devonion shale
			H	Blue Goose pool	Devonion shale

Pittsburgh coal to the Upper Devonian Genesee black shale (which lies directly on the Middle Devonian Tully Limestone), the majority of drilling and production centers on a few thousand feet of Upper Devonian rocks. In the classic area in and around Indiana County, drillers target the lower third of the Venango Group and the entire Bradford Group (Figure 30). The Elk Group provides some scattered subsidiary production, but is more developed to the north and east. On the eastern edge of the Appalachian Plateau, rocks equivalent to the Venango and Bradford Groups are known by their outcrop names of Lock Haven Formation to the north and Foreknobs and Scherr Formations to the south. Drilling in these rocks was spurred in 1984 when the Federal Energy Regulatory Commission, upon recommendation of the Pennsylvania Department of Environmental Resources, designated the Venango and Bradford Groups and the Catskill and Lock Haven Formations as "tight" formations throughout a large portion of western Pennsylvania. Under the NGPA, the "tight" designation allowed producers to charge higher prices for gas produced from these reservoirs, as much as \$7.012/Mcf by December 1989. Unfortunately for industry, the combination of increased production nationwide and record-setting warm winters during the decade created a gas surplus. Therefore, supply and demand, rather than the NGPA, regulated prices,

especially in the late 1980's. Prices actually paid for produced gas in 1989 were, on average, not much higher than those paid in 1980. It is interesting, in retrospect, to note that Pennsylvania's gas producers increased production annually (Figure 38) at the same time that they complained about the gas surplus. They were, in effect, helping to keep their own prices low by overproducing.

Several interesting shallow gas plays of the 1980's are discussed below.

"Kane Sand" Play. Significant new drilling, and the consequences of overdrilling, occurred in eastern Indiana County, southern Clearfield County, and western Cambria County during the early part of the decade as a result of the discovery, in the late 1970's, of gas in the "Kane sand." The "Kane" is the deepest of the Bradford Group sandstones, and south of Elk County, it is notorious for its water content. Because of this, most operators with any experience tend to drill no deeper than the "Third Bradford," the penultimate sandstone in the group. A narrow band of "Kane sand" in this area, which exhibits a well-developed submarine fan geometry (Johnson, 1984), contains gas, rather than water, in what is probably a fractured reservoir. Almost 60 percent of the wells that penetrated the "Kane" in this area experienced open flows greater than 4,000 Mcfgpd; open flows as high as 20,000

Mcfgpd were not unheard of, and reserves tended to be high as well. It is understandable, therefore, that the area attracted a great deal of attention. It is also unfortunate, however, that little was done to conserve the resource. Companies sprouted from the countryside overnight, as people who had money but little or no experience tried to take advantage of the new discovery of "black gold." Established companies that had planned careful programs of leasing, drilling, and production found themselves competing with newly formed groups willing to spend absurd amounts of money for equally absurd leases. In the end, too many wells were drilled in too small an area, too much gas was produced, and an inevitable decline occurred in the production of established wells and in the open-flow potentials of new wells. The lessons generated by numerous similar occurrences over the past 130 years, including the McKeesport gas field (1919–21) in Allegheny County and the Leidy gas field (1950–54) in Clinton and Potter Counties, were once again ignored.

Lock Haven Formation. Drilling for shallow targets in the eastern Plateau area had been sporadic until 1982. At that time, Eastern States Exploration Company, which had a lease on state forest lands that was about to expire, drilled a well. To everyone's surprise, the well blew in with a reported open flow of 1,958 Mcfgpd (the actual open flow has been rumored to be closer to 20,000 Mcfgpd), establishing the Lock Haven Formation as a bona fide producing formation. This was the discovery of the Council Run field (in the easternmost producing area in Figure 40), an area of Lock Haven drilling that now encompasses four or five townships in northern Centre County. Exploration for new reserves in the area resulted in the additional discovery of fields in adjacent Clinton County. The core producing zone of the Council Run field was a single sandstone lying at a depth of about 4,600 feet. Although most of the Lock Haven wells drilled during the decade had average production, approximately a dozen wells along a southwest-northeast trend, including the discovery well, had high open flows and outstanding production. These wells initiated a surge of activity by other companies to determine whether the trend was a fluke or a standard for the Lock Haven. Although there were other high-production wells, they were scattered throughout the total productive area. The Lock Haven is now considered to be basically an extension of the main producing area of Indiana, Clearfield, Cambria, and Westmoreland Counties. It has stimulated much interest in adjacent parts of Centre, Clinton, and

Lycoming Counties, and numerous companies have acquired leases. This is likely to become the "hot-test" shallow play of the 1990's in Pennsylvania.

Brallier Formation. The Upper Devonian Brallier Formation in outcrop is a sequence of fine-grained sandstones, siltstones, and shales forming cyclical, fining-upward sequences (turbidites). In the subsurface of Greene County in the 1980's, these turbidites provided operators, particularly Kepco, Inc., the opportunity to explore for gas reserves in a formation that had been largely ignored by the industry. The Brallier is not the most ideal formation in which to look for gas. Most of the gas production is from siltstones having very low porosities (1.9 to 3.0 percent) and permeabilities [0.12 to 0.39 mD (millidarcy)] (Laughrey, 1985), and the formation is considered to have marginally economic gas reserves. Despite this, 13 pools were discovered in these rocks during the decade (Figure 40). Higher gas prices helped stimulate this drilling, and with the fall of prices in the mid-1980's, the drilling stopped.

Unconventional Gas Resources. The future of shallow unconventional gas resources, that is, gas from Pennsylvanian and Permian coals and from Devonian shales, is still uncertain. Coal-bed methane began to attract a great deal of attention in other states during the 1980's. Studies of the methane potential in the San Juan basin of Texas and New Mexico and the Black Warrior basin of Alabama led the way for studies of the potential of the coals in the Northern Appalachian coal basin, including West Virginia and Pennsylvania. In an estimate of the probable undiscovered recoverable coal-bed methane resources in Pennsylvania, Geomega, Inc. (1983), concluded that more than 585 Bcf of natural gas can be produced from the bituminous coal fields of western Pennsylvania. This estimate included only the coals of the Allegheny and Monongahela Groups, however, and it is possible that Pottsville and Dunkard Group coals could also add to the total. However, the issue of coal-bed methane is currently in legal limbo. During the 1980's, the Pennsylvania State Supreme Court ruled that the natural gas in a coal seam belongs to the coal owner rather than to the holder of oil and gas rights. Inasmuch as the coal companies have not expressed interest in producing coal-bed methane, the court ruling places most of Pennsylvania's resources out of reach for the time being.

Pennsylvania's other unconventional resource, Devonian shale gas, may exceed 750 Bcf in probable undiscovered resources (Geomega, Inc., 1983). How-

ever, because of its great depth in the areas south and east of Erie County (up to 9,000 feet in places in Somerset County), it is unlikely that this large resource will be developed soon. In Erie County, gas has been produced from the shales for over 130 years. The shallow drilling depths (as little as 300 feet) provided great incentive to Erie home owners and small businesses in the late 1970's and early 1980's. For the price of a new large automobile (about \$10,000 in 1980), a family could drill a shale well to approximately 1,000 feet and hook the well into the home's heating and/or cooking system. Although the initial outlay was relatively high, the long-lived wells would eventually pay for themselves by saving their owners the cost of utility gas. However, the rising cost of drilling and completing wells, the stringent regulations set forth by the oil and gas law of 1985, and the stabilized or decreasing cost of gas from local utilities eventually made backyard gas wells economically unfeasible. Only a handful of domestic shale wells have been reported since the mid-1980's. All of the eight shale pools discovered during the decade (Figure 40) had been drilled by 1984.

Deep Gas

Deep-gas-well drilling accounted for 5,088, or 19 percent, of all of the wells reported during the 1980's. The average number of wells per year increased almost 900 percent over that reported for the 1970's (Figure 37). Unlike shallow wells, reported deep-gas-well drilling followed a trimodal distribution pattern during the decade (Figure 19). The first two peaks in drilling occurred in the same pattern as the shallow wells, but a third peak occurred in 1988 at a time when reported totals for shallow gas wells were falling off. The explanation for this phenomenon has nothing to do with geology or economics, but rather has to do with internal administration of records. In 1984, the field office of the Bureau of Oil and Gas Management in Pittsburgh was split, and all of the files for the northern counties of Pennsylvania, including those for the deep gas wells of the Lower Silurian Medina Group, were transferred to Meadville in Crawford County. The split caused a temporary cessation of record sharing between the Survey and the Bureau of Oil and Gas Management. Unrealized by both bureaus, copies of numerous well-completion reports and location plats were not transferred to the Survey. With the beginning of computerization and industry's compliance with newly passed reporting requirements for production (one of the provisions of Act 223), the Survey began finding many of the wells

that had slipped through the cracks in the system. Most of these wells were recorded during 1988 and 1989, accounting for the third peak in reporting during the decade.

Deep-gas production increased fairly steadily during the 1980's, from 14.9 Bcf in 1980 to 46.5 Bcf in 1989 (Figure 38). This represents a 213 percent increase. The large number of Medina wells drilled during the decade, as well as the excellent production capabilities of the less numerous Lower Devonian Ridgeley wells in south-central Pennsylvania, accounted for much of this trend.

Although shallow-gas-well drilling and production continued to be more prevalent than deep drilling and production, most of the truly exciting exploratory and development drilling during the 1980's occurred as a result of deep-gas-well activity. The rush to drill wells and produce gas from deep formations opened up reservoirs and areas of Pennsylvania previously unexplored or underexplored. For example, Wilmoth Industries had the first Pennsylvania production from the Middle Devonian Tully Limestone in Butler County in 1987. Although the Tully is known to have produced gas in New York since earlier this century (Kreidler, 1953), drillers considered it to be a better marker horizon than a viable target. In addition, natural gas from some rather exotic reservoirs, such as the Middle Devonian Onondaga Limestone, the Lower Devonian Bois Blanc Formation, and the Upper Silurian Bass Islands Dolomite and Salina Group, showed that even the difficult-to-evaluate carbonates of north-western Pennsylvania have gas in commercial quantities. Some other deep formations that attracted the attention of industry in the 1980's were the Lower Devonian and Upper Silurian Helderberg Group; the Middle Silurian Lockport Dolomite and its central Pennsylvania equivalent, the McKenzie Formation; the Lower Silurian Tuscarora Sandstone; the Upper Ordovician Bald Eagle Formation; and the Lower Ordovician Beekmantown Group. Discoveries were made in all but the McKenzie. The discovery of gas in the Bald Eagle Formation in Clinton and Lycoming Counties was, perhaps, the most important of these discoveries (see p. 50).

Huntersville Chert, Oriskany Sandstone, and Ridgeley Sandstone. Deep drilling began in earnest in Pennsylvania in the 1930's with the discovery of gas in the Ridgeley Sandstone ("Oriskany sand" of drillers) in Tioga County. The discovery of several very large fields in north-central Pennsylvania resulted in a drilling "boom" of sorts in the 1950's and 1960's that spread throughout the Appalachian

basin. Some of the wells in western Pennsylvania never actually produced from the Ridgeley, however, or produced by commingling with the overlying Middle Devonian Huntersville Chert. Today most fields have wells that produce from either the Huntersville or the Ridgeley, and in some cases from both, so that the two formations are considered to be inexorably linked in production. To add to the confusion, the Oriskany Sandstone, considered by the Survey to be a separate formation equivalent to the Ridgeley, produces only in northwestern Pennsylvania. It is separated from the Ridgeley by a broad northeast-trending zone in which the rocks of the Oriskany-Ridgeley interval are missing; the zone is called, appropriately enough, the "Oriskany no-sand area." This zone resulted from erosion or nondeposition of the sand on an area of positive relief overlying an uplifted basement fault block.

Figure 41 shows the distribution of fields and pools in the Huntersville Chert, Ridgeley Sandstone, and Oriskany Sandstone, with emphasis on those discovered during the 1980's. There were 55 new fields and pools in all, and although most of them were concentrated in Somerset and adjacent counties, many were scattered throughout the western half of the state.

The Oriskany is a very patchy sandstone whose precise distribution can only be approximated. Numerous areas occur throughout northwestern Pennsylvania where the overlying Bois Blanc Formation sits directly on Lower Devonian Helderberg or Bass Islands carbonate rocks. It appears from previous studies (e.g., Kelley and McGlade, 1969) that the thicker deposits of Oriskany Sandstone occur where dissolution of salt in the Upper Silurian Salina Group created swales that captured sand being washed over the area. Harper (1982) noted that many of these swales were subsequently deformed and are now structurally high, creating the near-ideal situation of relatively thicker reservoir sandstones on broad, low anticlines. Such conditions typically resulted in up-dip gas deposits driven by the down-dip pressure of reservoir waters.

Seven new Oriskany pools were discovered in northwestern Pennsylvania during the decade. Most of these were short-lived, one-well pools that were discovered serendipitously while the well was being drilled to the Medina Group. They have since either been plugged and abandoned or drilled deeper. Almost all of these discoveries had large open flows of gas, typically gauged in millions of cubic feet per day, but they soon watered out. A notable exception is the Derber pool in Mercer County (number

7 on Figure 41). Discovered in 1981, it had produced more than 0.5 Bcf of gas by the end of 1989. The exact production total is unknown because early production records are unavailable.

Drilling for Huntersville-Ridgeley gas accounted for 14 new fields and 35 new pools during the decade, most of them in the area of Westmoreland, Fayette, and Somerset Counties. These are very small numbers when compared with drilling in the Upper Devonian and in the Medina Group. The small numbers are understandable, however, when one considers that finding gas in these rocks is considerably more difficult and more costly than for the Upper Devonian and Medina Group reservoirs. Huntersville-Ridgeley reservoirs typically occur on the thrust-faulted flanks of rifted anticlines. Because of this structural complexity, determining where to drill must be based on seismic survey information. Add to this the excessive drilling depth of a typical Huntersville-Ridgeley well (as much as 10,000 feet in some parts of Somerset County), and the well commonly exceeds the financial resources of Pennsylvania's small independent companies. Because the average well has higher reserves and better production capabilities than either Upper Devonian or Medina wells, the pay out more than offsets the initial cost. Therefore, some of the larger independent companies and major oil companies find the Huntersville-Ridgeley an excellent target and well suited to their exploratory and development programs.

"Bass Islands Trend." In 1981, operators in Chautauqua County, New York, discovered a trend in the sequence of rocks from Middle Devonian Onondaga Limestone through Upper Silurian Bass Islands Dolomite that drew a great deal of attention from industry and academia. The Bass Islands trend, as it has become known, is long, narrow (approximately 1.5 miles wide), and arcuate, extending from Erie County, New York, through the narrow neck of Lake Chautauqua in Chautauqua County, New York, and southwestward into Erie County, Pennsylvania (Figure 42). The discovery well was a surprise; the well blew out, and after the fire was extinguished and the area cleaned up, it was estimated that the well had "produced" over 200 bbl of oil and an unknown amount of gas.

Patenaude and others (1986) used seismic survey information to delineate the trend in New York. They described it as a complex of very high angle reverse faults associated with detachment in the lower salt beds of the Salina Group. Upper and lower seals are provided by the Middle Devonian

LIST OF LOWER DEVONIAN FIELDS AND POOLS DISCOVERED IN THE 1980'S

NO.	FIELD OR POOL	RESERVOIR	NO.	FIELD OR POOL	RESERVOIR
1	McGuire pool	Oriskany	29	Laurel Ridge pool	Huntersville/Ridgeley
2	School pool	Oriskany	30	DuPree pool	Huntersville
3	Car Wash pool	Oriskany	31	Eberly pool	Huntersville
4	Center Bar pool	Oriskany	32	Glessner field	Ridgeley
5	Rogers pool	Oriskany	33	Brier Knob field	Ridgeley
6	South Wellsboro field	Ridgeley	34	Weaver Road pool	Ridgeley
7	Derber pool	Oriskany	35	Shafer Run pool	Ridgeley
8	Grove Hill pool	Ridgeley	36	Quemahoning pool	Huntersville
9	Weaver pool	Oriskany	37	Gideon pool	Ridgeley
10	Elora pool	Ridgeley	38	Shade pool	Huntersville/Ridgeley
11	Eagle Eye pool	Ridgeley	39	Lookout pool	Huntersville/Ridgeley
12	Gifford Run field	Ridgeley	40	Lavansville pool	Ridgeley
13	Parker Dam pool	Ridgeley	41	Somerset East field	Ridgeley
14	Wilgus pool	Ridgeley	42	Distillery pool	Huntersville/Ridgeley
15	Untontown pool	Huntersville	43	Lourel Hill pool	Ridgeley
16	Wandin pool	Ridgeley	44	Blue Hole pool	Huntersville/Ridgeley
17	Serro pool	Huntersville	45	Kimmel field	Ridgeley
18	Carney Run pool	Huntersville	46	Weimer pool	Ridgeley
19	Air Shaft pool	Huntersville/Ridgeley	47	Gebhart pool	Huntersville
20	Keystone pool	Huntersville	48	Harbaugh pool	Ridgeley
21	Penrod pool	Huntersville/Ridgeley	49	Kings Bridge field	Ridgeley
22	Linn Run field	Ridgeley	50	Cronberry Lake pool	Huntersville/Ridgeley
23	Silver Mine pool	Huntersville	51	Lower Turkeyfoot pool	Huntersville
24	Myersbrook pool	Huntersville	52	Paddytown field	Ridgeley
25	Krayn field	Ridgeley	53	Mt. Davis field	Huntersville Ridgeley
26	Pot Ridge field	Ridgeley	54	Tub Mill pool	Huntersville
27	Wymys Gap pool	Ridgeley	55	Weimer Run pool	Ridgeley
28	Spook Hill field	Huntersville/Ridgeley			

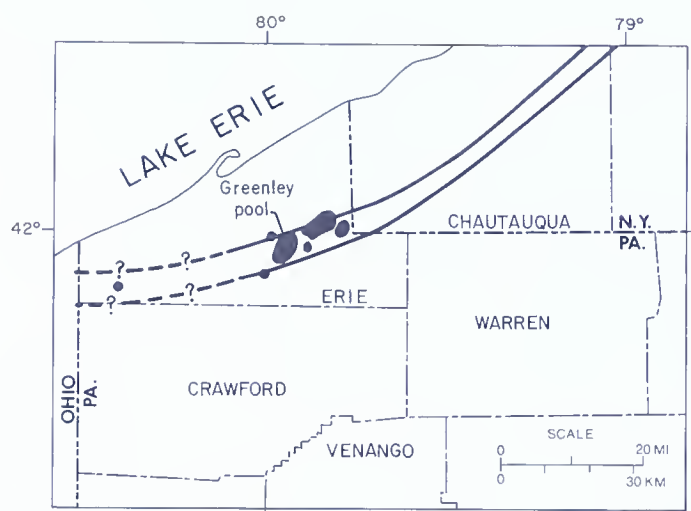


Figure 42. The "Bass Islands trend" in New York and Pennsylvania and the locations of fields and pools developed on or near it. The dashed lines indicate uncertainty concerning both the existence and the location of the trend.

Hamilton Group shales and the lowest anhydrite zone in the Salina, respectively.

The trend was first extended into Pennsylvania in 1983 with the discovery of the Greenley pool in the Drumlin field (Figure 42) when NRM Petroleum Corporation completed the #1 Mitchell well with an open flow of 4,108 Mcfgpd. The Drumlin field produces mainly from the Lower Silurian Medina Group at about 3,700 feet below sea level, but the Mitchell well penetrated a fractured carbonate zone at about 1,300 feet below sea level. Since the advent of the Greenley pool, at least three other pools within the trend have been discovered in Pennsylvania (Figure 42), one of which produces oil as well as gas.

Medina Group and Tuscarora Sandstone. Pennsylvania's oil and gas industry drilled more wells into the Medina Group during the 1980's than into all other deep formations combined since the search for oil and gas began in 1859. More than 5,000 wells, of which 4,955 were productive, penetrated the Medina in the five-county area of Erie, Crawford, Mercer, Venango, and Warren, as compared with the more than 3,600 deep wells drilled between the late 1800's and 1979. The Medina Group was the first formation in Pennsylvania to be designated a "tight" formation under the NGPA. The designation, made in 1981, spurred drilling during the first half of the decade. Although a substantial number of wells were still being reported at the end of the decade, drilling had fallen off significantly.

All of this drilling understandably had a large effect on the configuration of the Medina gas fields in northwestern Pennsylvania (Figure 43). The industry opened 16 new fields, all of which were discovered by 1984, and 99 new pools, most of which were discovered in the shallow oil fields of Crawford, Venango, and Warren Counties.

The Medina Group consists generally of low-porosity, low-permeability sandstones interbedded with shales (Laughrey, 1984). In this sense, the rocks are very similar to the Upper Devonian "bread-and-butter" sandstone reservoirs that have produced most of the oil and gas in Pennsylvania, and drillers familiar with the Upper Devonian have had fairly good success in the Medina. Two broad zones of production trending roughly northeast-southwest, a northern "shallow" zone and a southern "deep" zone, are separated by an equally broad swath where the Medina produces an unacceptable amount of water. The reservoirs basically have stratigraphic and/or diagenetic traps, but subtle structures may have a lot to do with good versus fair producing wells.

There was a brief flurry of drilling activity at the beginning of the decade in the Tuscarora Sandstone (the central Pennsylvania equivalent of the Medina Group), resulting in two new fields in Centre County, the Runville field in 1980 and the Black Moshannon field in 1982. Only a few wells were drilled in various localities during the remainder of the decade, and not one was successful. In Pennsylvania, Tuscarora gas is typically high in nonhydrocarbon gases, particularly nitrogen. This tends to lower the Btu level and make the gas less attractive to buyers. In general, such gas either must be cut with high methane gas or must have the nitrogen extracted before it can be sold. This problem, coupled with the complexity of the structural trap and the ultra-deep drilling depth (greater than 10,000 feet) of a typical Tuscarora well on the eastern edge of the Appalachian Plateau, tends to discourage most operators from taking the risk.

Bald Eagle Formation. In 1982, Texaco U.S.A. and Marathon Oil Company combined to drill a 19,365-foot test of the Cambrian in Clinton County, the second deepest hole in Pennsylvania. The prospect occurred above a large basement fault determined from seismic surveys, and it promised to be an interesting structural target. During drilling, the well encountered an anomalously large flow of gas in the Upper Ordovician Bald Eagle Formation (equivalent to the Oswego Formation of New

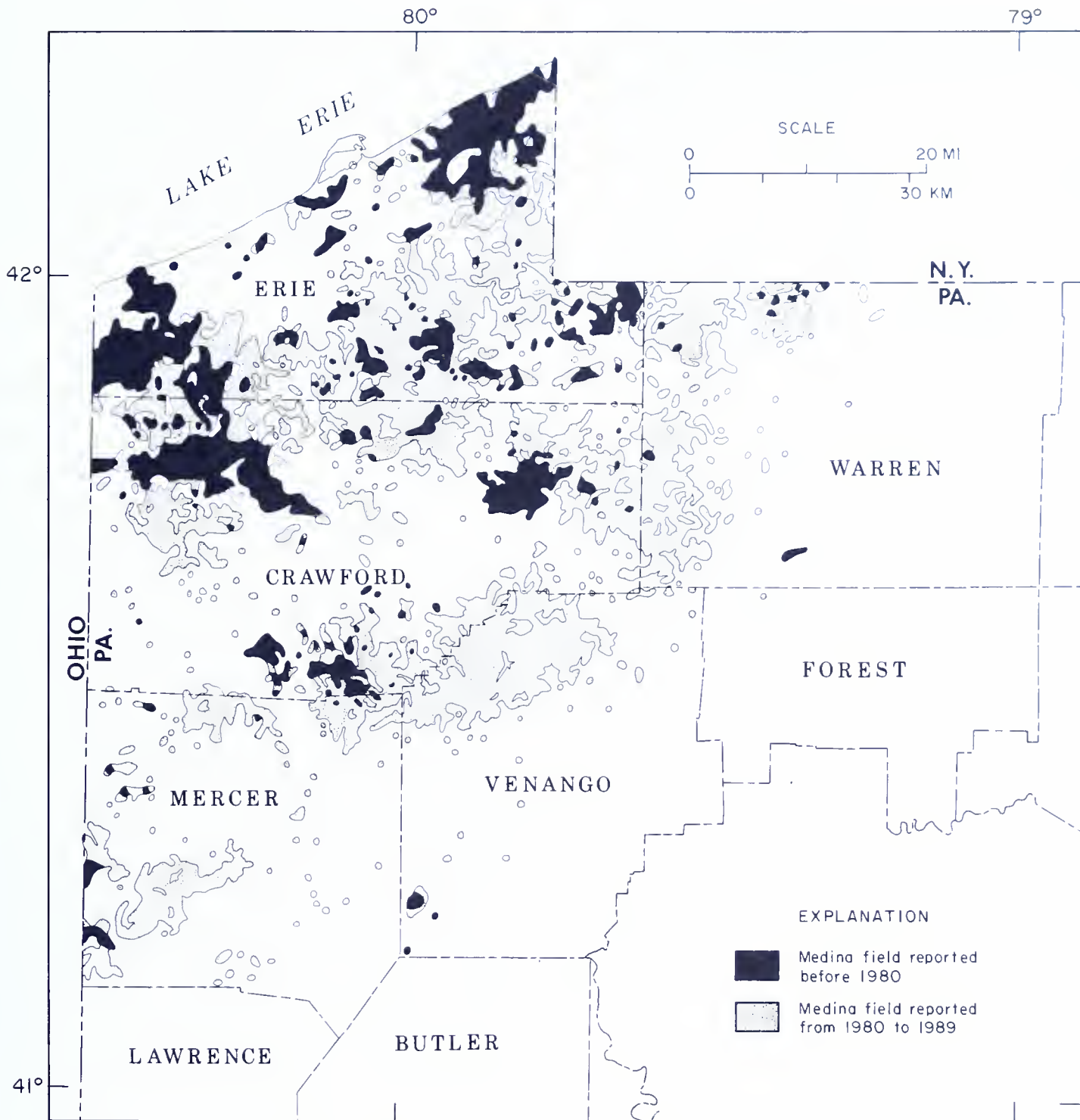


Figure 43. Changes in field coverage in northwestern Pennsylvania due to drilling of the Medina Group reservoirs during the 1980's.

York). Despite the flow, the companies continued to drill to the Cambrian where, as it turned out, they found nothing economical. In an attempt to regain at least some of their losses, the companies plugged back to the Bald Eagle and perforated the casing between 12,900 and 13,030 feet. They treated the perforations with acid to clean up the holes, but did little else. The well was subsequently gauged at

3,847 Mcfgpd with a rock pressure of 9,220 psi. A second well was drilled on the structure in 1985, and by the end of 1989, the two wells had produced 5.5 Bcf of gas.

Texaco filed for "tight" formation status on the Bald Eagle in the area of the two wells, submitting information indicating that matrix porosity and permeability were very low in the reservoir. The Penn-

sylvania Department of Environmental Resources rejected the filing, however. Harper and Laughrey (1986) performed an in-depth study of the geology and engineering characteristics of the reservoir rock, which was based in large part on the information Texaco submitted to the department as a part of the request. They determined that, although the matrix porosity and permeability of the Bald Eagle was, indeed, very low, the Bald Eagle produced from a highly fractured zone rather than from the matrix. Readers interested in the Bald Eagle of north-central Pennsylvania and its reservoir potential should find the recent dissertation by Lacazette (1991) especially intriguing.

PROSPECTIVE TRENDS FOR THE 1990'S

Attempting to predict the trends of the oil and gas industry in the 1990's may be compared to trying to predict which direction the Mississippi River will flow after a major flood. There will be numerous clues from the industry as to what will be "hot issues" during the next several years. However, the state of politics, economics, and the environment (and serendipity as well) commonly change with surprising rapidity, leaving prognosticators foolishly trying to determine where they went wrong. For example, one minor flare-up in the Middle East can impact the industry as much as a dozen new laws enacted on the state and federal level. The invention of a new engine powered by nonhydrocarbon fuels could devastate the entire world oil market. On the other hand, the discovery of new drilling, evaluation, or recovery technology, a major stabilized price increase, or a change in the national philosophy on the environment could spur the domestic industry to even greater activity than in the "boom" years of the early 1980's. Of course, these scenarios are highly unlikely, but they illustrate some of the possibilities that could affect the energy industry.

Future Supplies and Demand

There is a bewildering amount of factual, as well as speculative, information concerning the amounts and locations of oil and gas reserves in this country. The industry has a wealth of information, but most of it is based on the experiences of individual companies in small areas and tends to be locked away from outside inquiries. Government organizations have the wherewithal to apply the data on the state and national levels, but generally have little access to the data. As a result, those who are in-

terested in large-scale projections of future recoverable resources must provide their own data and, in many cases, their own methods of manipulating the data. This can lead to problems of misinterpretation by the provider, the user, or both. As such, the U.S. Geological Survey and Minerals Management Service have been both praised and criticized for their recent report on undiscovered hydrocarbon resources (Mast and others, 1989). Most of the criticism, primarily of the methodology used, has been justified. For example, the Association of American State Geologists, in a report issued while the U.S. Geological Survey and Minerals Management Service report was still in the open-file stage, found that reviewers generally had concerns about the inconsistent quality of the data used for the assessment (Association of American State Geologists, 1988). The reaction of the oil and gas industry has been far more critical, addressing resource figures considered too low to be realistic.

The U.S. Department of Energy, Energy Information Administration, predicted in 1990 that, because of declining domestic production and higher demands, oil imports to the United States would reach 10 to 15 million bopd by 2010 (U.S. Department of Energy, 1990); this country currently imports about 7 million bopd. Domestic crude oil production has been falling by 3.2 percent per year since the mid-1980's. Falling oil prices and stricter environmental laws are making more oil wells marginally economic, and the marginally economic wells are being plugged. This is as true in Pennsylvania as it is in the rest of the nation, and it is expected to continue through the 1990's.

Domestic natural gas production, on the other hand, is expected to grow by 20 to 30 percent by the year 2000, at least partly because of the increase in demand for cleaner fuels in electric-power generation. Imports, primarily from Canada, are also expected to grow. This should help to spur industry to increase drilling and production in Pennsylvania, where proven reserves and projected undiscovered resources of natural gas far exceed those of crude oil.

Potential New Areas and Reservoirs

There are areas and formations in Pennsylvania that received little, if any, attention from drillers during the 1980's. Some of these areas and formations have not been seriously evaluated for 25 years. Economics and public issues combined to put substantial parts of Pennsylvania out of reach of the average oil and gas company. With the increase in

prices during the early 1980's, many of these areas and formations began to appeal to those companies having the staff and resources needed to investigate them. However, with the decline in industry that took place during the decade, these areas and formations once again became out of reach. The following is an appraisal of these potential targets, four of which are illustrated in Figure 44.

North-Central and Northeastern Pennsylvania

Until the discovery of the Council Run field in 1982, there were only a few very small (fewer than 10 wells) shallow gas fields scattered throughout the area between Potter and Pike Counties in north-central and northeastern Pennsylvania. The surprising production of gas from the Lock Haven Formation in Centre and Clinton Counties and the equally surprising oil discovery in Bradford County (Brace Creek field, letter F in Figure 36) indicate that the shallow formations of north-central and northeastern Pennsylvania may hold large reserves of natural gas. Pennsylvania's drillers need to carefully evaluate both the geography and geology of this area for its potential. A concerted effort to gradually move the producing belt eastward and northward from the Council Run field area would be the best plan, rather than simply punching holes randomly throughout the Plateau. This would reduce the risk of too many spectacular failures by

establishing the limits of production gradually. No part of the northern Plateau should be ignored, from northwestern Tioga County to the shores of the Delaware River.

Lockport Dolomite

The Middle Silurian Lockport Dolomite and its equivalent formations have produced oil and gas from various places in the Appalachian basin for many years. Despite hydrocarbon shows in the Lockport throughout western Pennsylvania, however, only three small pools of Lockport production have been discovered. The first discovery was in the mid-1960's (the Kilgore pool in Mercer County). Two discoveries in the 1980's included the Cranesville pool in the Conneaut field, Erie County, and the Donation Hill pool in the Cooperstown field, Venango County. Both pools were discovered during drilling for Lower Silurian Medina Group production. Laughrey (1987) demonstrated that the Lockport has properties that separate it from the more commonly drilled sandstone reservoirs of western Pennsylvania and that most of the problems that the state's operators have encountered in the past stemmed from improper evaluation of geological and geophysical data. With a little training in proper log evaluation, Pennsylvania's operators could correct the errors of the past and make the Lockport a more positive target for future drilling.

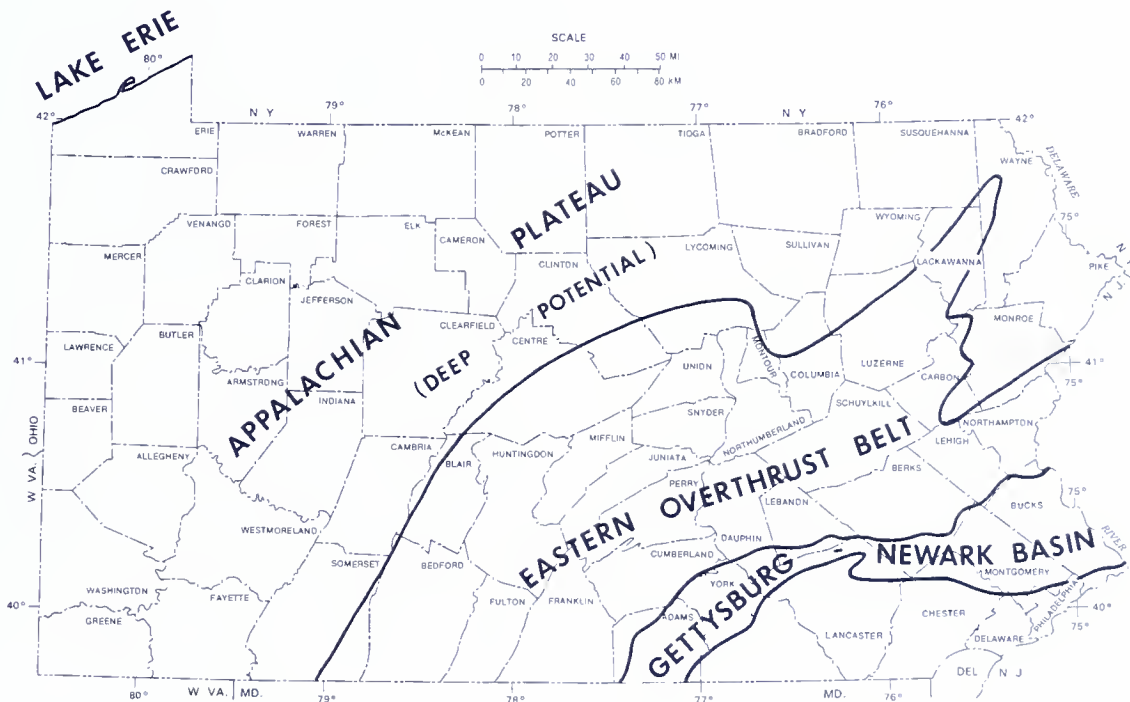


Figure 44. Four of the more important areas in Pennsylvania needing further evaluation of oil and gas resources.

Lake Erie

There is an enormous potential for finding natural gas, and probably oil, in the rocks underlying Lake Erie (Figure 44). The Medina Group, in particular, is a good target in the Pennsylvania portion of the lake. The Medina produces along the Lake Erie shoreline in both the United States and Canada, and in Canadian waters. Therefore, it is logical to assume that it would produce from beneath the American half of the lake as well. With the designation of the Medina as a "tight" formation in 1981, speculation was rampant in the newspapers that drilling in the lake would begin before 1983. However, environmental concerns prompted the governors of all of the states bordering the Great Lakes to agree on a moratorium on hydrocarbon exploration offshore.

Deeper Rocks of the Appalachian Plateau

With few exceptions, the oil and gas industry has not drilled very deeply into the Appalachian Plateau of western and north-central Pennsylvania (Figure 44). In northwestern Pennsylvania, the limit of drilling commonly is the top of the Upper Ordovician Queenston Formation. Throughout the remainder of the Plateau, the limit has typically been Lower Devonian or Upper Silurian carbonate rocks. Only about 60 of the estimated 300,000 wells drilled in the state have penetrated as deeply as the top of the carbonate rocks in the Ordovician and Cambrian Systems (Trenton and deeper) of western Pennsylvania, and only five of these have penetrated the entire Paleozoic section. Although there may be potential in Ordovician rocks (several wells have had shows of oil and gas, and one well, drilled in Warren County in the 1980's, is currently producing from Middle Ordovician dolomites), the rocks of the Upper Cambrian are more likely to produce oil and gas than any other deep formations.

The Upper Cambrian Gatesburg Formation consists of interbedded dolostones and sandstones that may contain a variety of hydrocarbons as well as water. One segment of this interbedded rock, called the "Rose Run sand," has caught the attention of Ohio drillers because of substantial oil and gas production and reserves. Fields are developed where a large unconformity of Early and Middle Ordovician age intersects the slightly deformed "Rose Run." In Pennsylvania, only about three dozen "Rose Run" wells have been drilled, mostly during the 1960's, and only two of these have ever produced. One of these wells, the Transamerican Petroleum #1 Scull in northwestern Crawford County,

produced 190,000 Mcf of gas and 1,100 bbl of condensate during the 18 months it was on line. This averages out to about 350 Mcf/day and 2 bbl/day. After 18 months, the well was shut in. When it was eventually opened again, water had penetrated the producing zone, and the well had to be plugged. "Rose Run" production occurs as a result of subtle stratigraphic and structural traps that require high-resolution seismic surveying to find. The "hit-or-miss" method of drilling used by most Pennsylvania drillers will not work with this reservoir, and the drilling depths of 6,000 to 9,000 feet in the three-county area requires a substantial investment. The average driller who is used to drilling relatively low-cost Medina wells is not likely to drill "Rose Run" wells without assurance that his exploration effort will pay off. However, if substantial reserves such as those found in eastern Ohio can be located in northwestern Pennsylvania, the "Rose Run" is likely to become a major new reservoir in this state.

Eastern Overthrust Belt

One of the most discussed prospects of oil and gas potential in the 1980's was the area commonly called the Eastern Overthrust Belt (Figure 44), in reference to its similarities with the productive Western Overthrust Belt (the Rocky Mountain area). Depending on one's philosophy, the Eastern Overthrust Belt included only the folded and faulted Appalachians (the Ridge and Valley), the folded and faulted Appalachians plus the Piedmont and Blue Ridge, or all of the deformed rocks of the Appalachians, including the slightly wrinkled rocks of the Appalachian Plateau. The concept became especially interesting with the suggestion, based on seismic survey work in the southern Appalachians, that the Piedmont and Blue Ridge had been thrust tens of miles over essentially flat-lying sedimentary rocks of Cambrian and Ordovician age. It was suggested that such sedimentary rocks may contain large volumes of hydrocarbons. Despite the excitement, no one was willing to drill through several miles of crystalline rock to find out if the idea had any merit. Instead, the few companies that could afford to drill in the overthrust belt concentrated on the fold belt. In Pennsylvania, the major oil companies, such as Amoco, Arco, and Exxon, drilled wells on seismic survey targets from Bedford County in south-central Pennsylvania to Northumberland County in eastern Pennsylvania, all without success.

This does not mean that the Eastern Overthrust Belt is unproductive. On the contrary, the prolific Ridgeley Sandstone fields of Bedford County, dis-

covered in the early 1960's, are evidence that some of the structures and formations in the overthrust belt hold high potential. This was further substantiated in the 1980's with the drilling of several productive Ridgeley wells in the vicinity of Keyser, West Virginia. Realizing the potential of the Eastern Overthrust Belt lies in discovering these structures and formations. Aside from the wells drilled in the Bedford County fields, to date only three to four dozen wells have been drilled in all of the folded Appalachians of central and eastern Pennsylvania. This is not nearly enough drilling to competently evaluate an area of such structural and stratigraphic complexity.

Mesozoic Basins

In 1985 and 1987, North Central Oil Company, a Texas-based independent, drilled remote wildcat wells in southeastern Pennsylvania, one each in Bucks and Montgomery Counties (Figure 45). These wells were tests of the lower Mesozoic Newark Supergroup rocks of the Newark basin (Figure 44), one of a series of Mesozoic-age rift basins developed during the breakup of the Pangea supercontinent about 225 million years ago. These basins occur in North America from New England to Georgia; similar basins also occur on the west coast of Africa. North Central had permitted the Bucks County well to 14,000 feet, but reached total depth at 10,500 feet. There were no reported shows of production of hydrocarbons on the official record, but the geophysical logs indicate that the rocks were capable of producing small amounts of natural gas (probably in the same production range as a shale well). As such, the well may have been commercially viable because of its proximity to the major eastern gas markets, particularly the Philadelphia area, but North Central quickly plugged and abandoned it. Not much is known about the Montgomery County well either; the company quickly plugged and abandoned it and only submitted a plugging certificate. There are no well records, geophysical logs, or drill cuttings available for study.

Geochemical analyses of drill cuttings from the Bucks County well demonstrated the presence of good to excellent, but spent, source rocks in the Newark Supergroup. This indicates that hydrocarbons were definitely generated in the past, but they do not appear in quantity in the rocks today. What happened? Did these hydrocarbons survive the intense thermal history of the region (intrusion by diabase dikes in the Late Triassic and Early Jurassic)? If so, where did they go? These are ques-

tions that will have to be answered if the Mesozoic basins, and in particular the Newark basin, are ever to be seen as viable frontier areas in Pennsylvania.

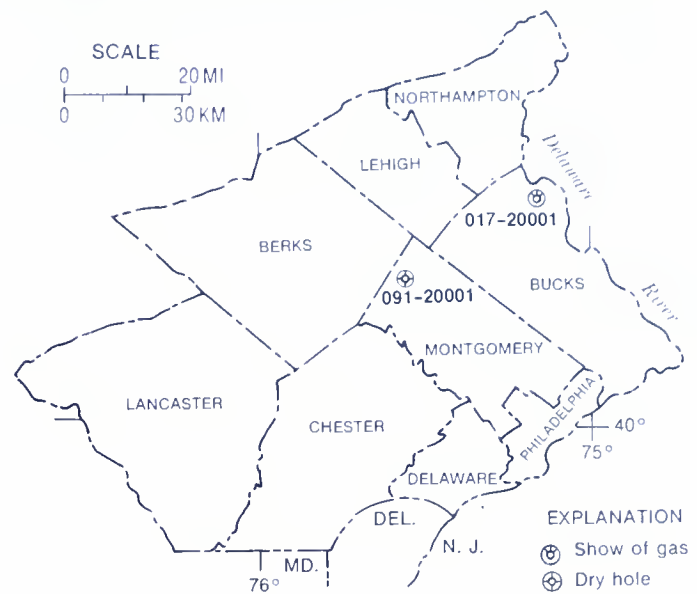


Figure 45. Locations of two wells drilled into the Triassic and Jurassic rocks of the Newark basin in southeastern Pennsylvania in the 1980's.

SUMMARIZED RECORDS OF REPORTED DEEP WELLS¹ IN 1990

by Christopher D. Laughrey and Cheryl L. Cozart

The information shown in Figure 47 at the back of this report was compiled mainly from drillers' logs, location plats, and geophysical logs received from the Bureau of Oil and Gas Management, as well as personal communication with oil and gas operators.

Most of the formation tops and total depths recorded in Figure 47 were picked from geophysical logs of many varieties (see Figure 46 for lists of these logs and their abbreviations). The logs received for a particular well are listed in Figure 47 along with the logged interval. If the box for geophysical logs is blank, no geophysical logs were received, and formation picks were taken directly from the driller's log. For some wells, only a small portion of a geophysical log was submitted; in these cases, the logged interval was noted, and a combination of the driller's log and geophysical log was used. Records are listed in Figure 47 alphabetically by county and numerically by permit number.

¹Wells that penetrate rocks of Middle Devonian or older age.

Figure 46. Types of geophysical logs and abbreviations.

Caliper	CAL
Cement bond log	CBL
Compensated density log	CDL
Continuous directional	CDR
Compensated neutron log	CNL
Dual induction log	DIL
Dipmeter	DIP
Dual laterolog	DLL
Electromagnetic propagation	EPT
Fracture identification log	FIL
Guard	GD
Gamma ray	GR
Gamma-ray spectralog	GRSPECTAL
Induction log	IL
Computer interpretative	INT
Lithodensity log	LDT
Laterolog	LL
Merge	MERGE
Microspherically focused log	MSFL
Perforating collar log	PCL
Sibilation	S
Sidewall neutron porosity	SNP
Sonic	SON
Temperature	T
3-D velocity	3-D VEL
Radioactive tracer	TRACER
Variable density log	VDL

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Figure 47. Summarized records of reported deep wells in 1990 that penetrated rocks of Middle Devonian or older age.

COUNTY PERMIT NUMBER	Cambria 021-20788	Clearfield 033-23240	Clinton 035-20375	Clinton 035-20439	Clinton 035-20441	Crawford 039-21584	Crawford 039-21963	Crawford 039-23084	Crawford 039-23110	Crawford 039-23111
NAME OF WELL	Bethlehem Steel #1-S	Yusukis, A. #1	PA State TR 679 #1	DER Tract 15 #R437	DER Tract 15 #R438	Mehalso-Tipton #1	Venango Valley #2	Pritchard, Perry #1	Goring #2	Worton #1
OPERATOR	Petroleum Development Corp.	Fairman Drilling Co.	Felmont Oil Corp.	CNG Transmission Corp.	CNG Transmission Corp.	Atlas Resources, Inc.	Meridian Exploration Corp.	Douglas Oil & Gas, Inc.	Douglas Oil & Gas, Inc.	Douglas Oil & Gas, Inc.
TOWNSHIP	Cambria	Sandy	Chapman	Chapman	Chapman	Spring	Venango	Sparta	Sparta	Sparta
QUADRANGLE	Nanty Glo	DuBois	Glen Union	Young Womens Creek	Young Womens Creek	Conneautville	Edinboro South	Spring Creek	Spring Creek	Spring Creek
LATITUDE	930 ft. S 40°30'00"	650 ft. S 41°05'00"	7,200 ft. S 41°22'30"	11,150 ft. S 41°30'00"	9,100 ft. S 41°30'00"	6,500 ft. S 41°50'00"	8,200 ft. S 41°47'30"	4,440 ft. S 41°50'00"	12,100 ft. S 41°52'30"	1,300 ft. S 41°50'00"
LONGITUDE	5,270 ft. W 78°05'00"	6,150 ft. W 78°04'00"	5,280 ft. W 77°35'00"	11,100 ft. W 77°42'30"	10,450 ft. W 77°42'30"	9,500 ft. W 80°15'00"	2,600 ft. W 80°07'30"	8,900 ft. W 79°35'00"	11,075 ft. W 78°05'00"	9,000 ft. W 79°35'00"
DATE COMPLETED	5-22-90	5-5-90	12-15-88	1-4-90	1-8-90	5-11-82	7-14-83	10-18-90	9-19-89	10-23-89
ELEVATION	2091 GR	1615 GR	1950 GR	1665 GR	1653 GR	1275 GR	1390 GR	1670 GR	1860 GR	1695 GR
LOGS RECEIVED AND LOGGED INTERVALS	LDT/CNL: 0-9085 DIL: 0-9085 INT: 0-445	CDL/CNL: 1530-3616 DIL/CNL: 3623-7620 INT: 1530-3616		CDL/CNL: 0-6724 DIL/CNL: 1340-6740 CBL/PCL: 0-6607 INT: 6500-6700	CDL/CNL: 1214-6683 DIL/CNL: 1214-6700 T/GR: 0-4519 INT: 0-6650	CDL/CNL: 215-4076 LL: 2429-4073 PCL: 3650-4008 INT: 3710-3955		CDL/DLL: 3300-5134	CDL/DLL: 3466-5220	
TULLY LIMESTONE	7750-	6724-	7028-	5705-	5682-	2332-		3372-	3504-	3358-
ONONDAGA LIMESTONE	8590- 8608-	7286- 7294-	8038-	6550-	6497-	2518-		3626-	3758-	3609-
ORISKANY SANDSTONE	8681-	7360-	8058-	6568-	6514-					
SILURIAN-DEVONIAN CARBONATES	8708-	7384-	8189-	6608-	6560-	2720-	3023-	3778-	3910-	3764-
SALINA GROUP LOCKPORT DOLOMITE			8545- 9505-			2794- 3416-		3843- 4476-	3968- 4589-	3818- 4450-
POCHESTER SHALE IRONDEQUOIT DOLOMITE			10479-			3653- 3726-		4762- 4812-	4882- 4926-	4741- 4790-
GRIMSBY FORMATION CAROT HEAD SHALE WHIRLPOOL SANDSTONE						3763- 3894- 3932-	4240-	4864- 4982- 5016-	4975- 5095- 5132-	4840- 4960- 4996-
QUEENSTON FORMATION						3937-	4430-	5030-	5148-	5008-
PRODUCING FORMATION		Bradford	Bald Eagle	Ridgeley	Ridgeley	Medina		Medina	Medina	Medina
DEEPEST PRODUCING DEPTH		304.7	13253	6572	6538	3938		5022	5053	4942
TOTAL DEPTH	9091	7427	13494	6758	6720	4155	4440	5165	5236	5117
DEEPEST FORMATION REACHED	Helderberg	Helderberg	Reedsville	Helderberg	Helderberg	Queenston	Queenston	Queenston	Queenston	Queenston
RESULTS	Dry and abandoned exploratory (NFW) Unnamed field	267 Mcf AF 10826 psi/48 hrs. development Punxsutawney-Driftwood field	110 Mcf AF 5210 psi/80 hrs. exploration (EX) Grapen field	179 Mcf AF 2331 psi/24 hrs. development Greenlick Storage pool Leidy field	8245 Mcf AF 2372 psi/24 hrs. development Greenlick Storage pool Leidy field	2000 Mcf AF 1700 psi/10 hrs. development Indian Springs Carbont field	Dry and abandoned exploratory (NFW) Unnamed field	4700 Mcf AF 1375 psi/48 hrs. development Eastman Hill pool Sparta field	3600 Mcf AF 1300 psi/48 hrs. development Eastman Hill pool Sparta field	3500 Mcf AF 1350 psi/48 hrs. development Eastman Hill pool Sparta field

Figure 47. (Continued).

COUNTY PERMIT NUMBER	Crawford 039-23115	Crawford 039-23118	Crawford 039-23121	Crawford 039-23127	Crawford 039-23130	Crawford 039-23135	Crawford 039-23141	Crawford 039-23144	Crawford 039-23146	Crawford 039-23150
NAME OF WELL	Roeder, E. #4	Lukach, P. #1	Schweitzer #2	Gavin, J. #1	Sparta Sportsmens #1	Gilbert, Karl #1	Hasbrouck, N. #2	Vergara, J. #2	Molcan, Joseph #1	Oaks, Jessie #2
OPERATOR	Wainoco Oil & Gas Co.	Wainoco Oil & Gas Co.	Wainoco Oil & Gas Co.	Mark Resources Corp.	Douglas Oil & Gas, Inc.	Quaker State Corporation	Wainoco Oil & Gas Co.	Shearer, James I. Company	James Drilling Corp.	James Drilling Corp.
TOWNSHIP	Rome	Rome	Sparta	Oil Creek	Sparta	Randolph	Rome	Beaver	Beaver	Beaver
QUADRANGLE	Titusville North	Titusville North	Lake Canadonha	Titusville North	Spartansburg	Townville	Titusville North	Beaver Center	Beaver Center	Beaver Center
LATITUDE	9,470 ft. S 41°45'00"	2,320 ft. S 41°45'00"	3,530 ft. S 41°44'30"	9,580 ft. S 41°42'30"	1,350 ft. S 41°50'00"	9,750 ft. S 41°40'00"	12,540 ft. S 41°45'00"	10,840 ft. S 41°47'30"	6,070 ft. S 40°47'30"	7,470 ft. S 41°47'30"
LONGITUDE	2,630 ft. W 79°37'30"	6,680 ft. W 79°42'30"	4,750 ft. W 79°45'00"	4,240 ft. W 79°37'30"	4,550 ft. W 79°37'30"	3,450 ft. W 79°55'00"	2,980 ft. W 79°37'30"	3,900 ft. W 80°27'30"	2,440 ft. W 80°27'30"	9,300 ft. W 80°25'00"
DATE COMPLETED	10-11-89	10-27-89	11-2-89	12-19-89	11-30-89	12-9-89	10-4-89	11-6-89	10-19-89	11-14-89
ELEVATION	1632 GR	1483 GR	1522 GR	1642 GR	1650 GR	1520 GR	1635 GR	1100 GR	1094 GR	1132 GR
LOGS RECEIVED AND LOGGED INTERVALS	CDL/CNL: 3580-5452 GD/GR: 3580-5452 INT: 3580-5452	CDL/CNL: 4200-5140	CDL/CNL: 3150-4982	CBL/GR: 4100-5560	CDL/DLL: 3275-5054		CDL/CNL: 3600-5504 GD/GR: 3600-5504 INT: 3600-5504	CDL/GR: 250-3446 GD/GR: 3550-3842 CNL/GR: 3550-3751	CDL/GR: 300-3794 GD/GR: 3500-3786 CNL/GR: 3500-3750	CDL/GR: 200-3820 GD/GR: 3550-3810 CNL/GR: 3550-3790
TULLY LIMESTONE	3645-		3193-	3752-	3296-	3410-	3663-	2332-		
ONONDAGA LIMESTONE										
HUNTERSVILLE CHERT	3908-		3430-	4017-	3540-	3633-	3926-		2318-	2368-
ORISKANY SANDSTONE										
RIDGELEY SANDSTONE	4050-			4147-		3795-	4072-			
SILURIAN-DEVONIAN CARBONATES	4056-		3598-	4171-		3810-	4075-	2542-	2542-	2580-
SALINA GROUP	4124- 4772-	4430-	3558- 4283-	4284- 4880-	3746- 4388-	3914- 4320-	4142- 4790-	2624- 3270-	2612- 3212-	2652- 3262-
LOCKPORT DOLOMITE										
ROCHESTER SHALE	5055- 5118-	4702- 4762-	4562- 4616-	5197- 5268-	4664- 4728-	4790- 4893-	5070- 5138-	3507- 3576-	3496- 3542-	3548- 3596-
IRONDEQUOIT DOLOMITE										
GRIMSBY FORMATION	5168- 5282- 5328-	4814- 4942- 4972-	4664- 4785- 4822-	5325- 5448- 5485-	4778- 4895- 4930-	4961- 5066- 5112-	5188- 5312- 5351-	3610- 3736- 3787-	3575- 3662- 3743-	3629- 3710- 3750-
CAROT HEAD SHALE										
WHIRLPOOL SANDSTONE										
QUEENSTON FORMATION	5340-	4986-	4828-	5496-	4945-	5131-	5362-	3792-	3748-	3778-
PRODUCING FORMATION	Medina	Medina	Medina	Medina	Medina	Medina	Medina	Medina	Medina	Medina
DEEPEST PRODUCING DEPTH	5337	4980	4764	5442	4882	5127	5358	3699	3706	3773
TOTAL DEPTH	5449	5134	4972	5593	5071	5280	5501	3830	3797	3822
DEEPEST FORMATION REACHED	Queenston	Queenston	Queenston	Queenston	Queenston	Queenston	Queenston	Queenston	Queenston	Queenston
RESULTS	IP not reported 1100 psi/72 hrs. development Vrooman Church Run field	696 Mcf AF 1140 psi/72 hrs. development Rome Athens field	1122 Mcf AF 595 psi/72 hrs. development Brimstone Athens field	474 Mcf AF 1040 psi/72 hrs. development Vrooman Church Run field	4200 Mcf AF 1300 psi/48 hrs. development Eastman Hill sparta field	1800 Mcf AF 1170 psi/48 hrs. exploratory (NFW) Turkey Track field	880 Mcf AF 1130 psi/72 hrs. development Vrooman Church Run field	161 Mcf AF 1075 psi/24 hrs. development Forro Conneaut field	153 Mcf AF 1050 psi/24 hrs. development Indian Springs pool Conneaut field	241 Mcf AF 1100 psi/24 hrs. development Indian Springs pool Conneaut field

COUNTY PERMIT NUMBER	Crawford 039-23151	Crawford 039-23154	Crawford 039-23160	Crawford 039-23161	Crawford 039-23162	Crawford 039-23163	Crawford 039-23164	Crawford 039-23165	Crawford 039-23166	Crawford 039-23167
NAME OF WELL	Miller, E. T. #1	Fox, Dale #2	Boythe, A. #1	Cochran Agency #1	Pier/Edwards #1	Rennie/Boythe #1	Morris, Fred #4	Morris, Fred #3	Kolaja, Lynn #1	Morris, Fred #5
OPERATOR	James Drilling Corp.	Cabot Oil & Gas Corp.	Douglas Oil & Gas, Inc.	Wainoco Oil & Gas Co.	Mark Resources Corp.	Douglas Oil & Gas, Inc.	Wainoco Oil & Gas Co.	Wainoco Oil & Gas Co.	Wainoco Oil & Gas Co.	Wainoco Oil & Gas Co.
TOWNSHIP	Beaver	Troy	Sparta	Rome	Oil Creek	Sparta	Rome	Rome	Sparta	Rome
QUADRANGLE	Beaver Center	Centerville	Spartansburg	Spartansburg	Titusville North	Spring Creek	Titusville North	Titusville North	Spartansburg	Titusville North
LATITUDE	9,610 ft. S 41°47'30"	14,700 ft. S 41°42'30"	5,225 ft. S 41°50'00"	9,220 ft. S 41°47'30"	5,290 ft. S 41°42'30"	7,300 ft. S 41°50'00"	11,980 ft. S 41°45'00"	8,850 ft. S 41°45'00"	3,630 ft. S 41°47'30"	10,070 ft. S 41°45'00"
LONGITUDE	8,350 ft. W 80°27'30"	8,180 ft. W 79°45'00"	950 ft. W 79°37'30"	2,550 ft. W 79°37'30"	2,290 ft. W 79°37'30"	8,575 ft. W 79°35'00"	9,070 ft. W 79°37'30"	8,390 ft. W 79°37'30"	3,900 ft. W 79°42'30"	9,500 ft. W 79°37'30"
DATE COMPLETED	11-14-89	11-18-89	11-15-89	11-13-89	12-4-89	11-21-89	11-29-89	11-21-89	12-20-89	12-14-89
ELEVATION	1103 GR	1415 GR	1610 GR	1682 GR	1543 GR	1570 GR	1502 GR	1550 GR	1385 GR	1550 GR
LOGS RECEIVED AND LOGGED INTERVALS	CDL/GR: 250-3791 CNL/GR: 3520-3761	CDL/GR: 0-5157 DLL/GR: 898-5174	COL/DLL: 0-5068	CDL/CNL: 3500-5360	CBL/GR: 3600-5405	COL/DLL: 514-5044	CDL/CNL: 3450-5328	CDL/CNL: 3450-5352	CDL/CNL: 3050-4894	CDL/CNL: 3500-5374
TULLY LIMESTONE	3434-	3672-	3313-	3537-	3625-	3281-	3514-	3516-	3097-	3538-
ONONDAGA LIMESTONE HUNTERSVILLE CHERT	2312-	3672-	3563-	3792-	3891-	3532-	3570-	3772-	3338-	3792-
ORISKANY SANDSTONE RIDGLEY SANDSTONE	3826-				4024-		3912-	3916-		3938-
SILURIAN-DEVONIAN CARBONATES	3845-		3716-	3942-	4040-	3682-	3920-	3923-	3512-	3950-
SALINA GROUP LOCKPORT DOLOMITE	3920- 4560-		3780- 4410-	4008- 4658-	4158- 4738-	3750- 4386-	3986- 4634-	3992- 4628-	3560- 4200-	4012- 4650-
ROCHESTER SHALE IFONDEQUOIT DOLOMITE	4842- 4904-		4701- 4746-	4942- 5002-	5041- 5128-	4672- 4724-	4910- 4978-	4908- 4976-	4478- 4536-	4928- 4996-
GRIMSBY FORMATION CAROT HEAD SHALE WHIRLPOOL SANDSTONE	4956- 5090- 5122-		4797- 4915- 4950-	5053- 5172- 5212-	5237- 5275- 5343-	4774- 4894- 4928-	5032- 5158- 5194-	5026- 5160- 5192-	4584- 4704- 4744-	5048- 5174- 5208-
QUEENSTON FORMATION	5131-		4966-	5222-	5355-	4938-	5204-	5203-	4758-	5220-
PRODUCING FORMATION	Medina	Medina	Medina	Medina	Medina	Medina	Medina	Medina	Medina	Medina
DEEPEST PRODUCING DEPTH	3673	5004	4893	5216	5349	4934	5200	5157	4698	5213
TOTAL DEPTH	3793	5210	5085	5332	5506	5064	5330	5334	4862	5369
DEEPEST FORMATION REACHED	Queenston	Queenston	Queenston	Queenston	Queenston	Queenston	Queenston	Queenston	Queenston	Queenston
RESULTS	244 Mcf AF 1100 psi/24 hrs. development Forro Conceaut field	IP not reported 1310 psi/48 hrs. development Diamond Troy field	3900 Mcf AF 1360 psi/48 hrs. development Eastman Hill pool Sparta field	730 Mcf AF 1170 psi/72 hrs. development Hatchtown pool Church Run field	155 Mcf AF 1325 psi/768 hrs. development Vrooman pool Church Run field	3300 Mcf AF 1360 psi/48 hrs. development Eastman Hill pool Sparta field	1700 Mcf AF 1010 psi/72 hrs. development Vrooman pool Church Run field	1600 Mcf AF 770 psi/72 hrs. development Vrooman pool Church Run field	381 Mcf AF 1100 psi/72 hrs. development Brimstone pool Athens field	311 Mcf AF 920 psi/72 hrs. development Vrooman pool Church Run field

Figure 47. (Continued).

COUNTY PERMIT NUMBER	Crawford 039-23168	Crawford 039-23169	Crawford 039-23170	Crawford 039-23173	Crawford 039-23181	Crawford 039-23183	Crawford 039-23188	Crawford 039-23192	Crawford 039-23198	Erie 049-21037
NAME OF WELL	Reese, Jon #2	Rennie #1	Orake, Richard #1	Bean #2	Greene, John #3	Burns, Essie #2	Pier/Edwards #2	Reese Unit #1	Shreffler, T. R. #1	Craig, J. #1
OPERATOR	Cabot Oil & Gas Corp.	Douglas Oil & Gas, Inc.	Wainoco Oil & Gas Co.	Greene, John W. Sr. Company	Greene, John W. Sr. Company	Sandstone Resources, Inc.	Mark Resources Corp.	Mark Resources Corp.	Mark Resources Corp.	Northwest Natural Gas Co.
TOWNSHIP	Wayne	Sparta	Rome	Spring	Spring	Cussewago	Oil Creek	Wayne	Troy	Conneaut
QUADRANGLE	Sugar Lake	Spring Creek	Spartansburg	Beaver Center	Beaver Center	Conneautville	Titusville North	Sugar Lake	Dempseytown	Conneautville
LATITUDE	14,870 ft. S 4,1037'30"	5,850 ft. S 4,1050'00"	15,000 ft. S 4,1047'30"	14,150 ft. S 4,1050'00"	13,150 ft. S 4,1050'00"	14,850 ft. S 4,1050'00"	5,300 ft. S 4,1042'30"	650 ft. S 4,1035'00"	8,710 ft. S 4,1037'30"	4,000 ft. S 4,1052'30"
LONGITUDE	10,500 ft. W 79,055'00"	9,400 ft. W 79,035'00"	5,430 ft. W 79,040'00"	8,150 ft. W 80,022'30"	7,075 ft. W 80,022'30"	1,980 ft. W 80,015'00"	180 ft. W 79,037'30"	8,720 ft. W 79,055'00"	2,980 ft. W 79,050'00"	7,750 ft. W 80,020'00"
DATE COMPLETED	12-20-89	1-16-90	12-18-89	12-28-89	6-16-90	3-5-90	8-29-90	8-20-90	8-27-90	6-25-80
ELEVATION	1470 GR	1610 GR	1699 GR	1012 GR	1032 GR	1270 GR	1638 GR	1422 GR	1503 GR	1050 GR
LOGS RECEIVED AND LOGGED INTERVALS	PCL/GR: 4980-5271	COL/OLL: 3269-5052	COL/CNL: 3450-5384	COL/CNL: 2000-3763		COL/GR: 2400-4142 OLL/GR: 2400-4142				
TULLY LIMESTONE	3457-	3303-	3582-	2052-	2064-	2448-	3730-	3439-	3593-	
ONONDAGA LIMESTONE HUNTERSVILLE CHERT	3674-	3556-	3826-	2220-	2233-	2633-	3998-	3641-	3824-	
ORISKANY SANDSTONE RIDGELEY SANDSTONE	3842-		3978-	2448-	2517-		4128-	3803-	3968-	
SILURIAN-DEVONIAN CARBONATES	3868-	3708-	3990-	2456-		2833-	4150-	3832-	3988-	
SALINA GROUP LOCKPORT DOLOMITE	4160- 4589-	3776- 4406-	4044- 4664-	2534- 3169-	2706- 3150-	2908- 3532-	4263- 4874-	3965- 4608-	4127- 4784-	
ROCHESTER SHALE IRONDEQUOIT DOLOMITE	4942- 5006-	4490- 4742-	4950- 5008-	3404- 3472-		3792- 3844-	5179- 5244-	4912- 4974-	5070- 5133-	
GRIMSBY FORMATION CAROT HEAD SHALE WHIRLPOOL SANDSTONE	5054- 5194- 5232-	4792- 4918- 4948-	5058- 5170- 5216-	3507- 3638- 3682-	3489- 3670-	3870- 4006- 4052-	5357- 5440- 5459-	5074- 5170- 5200-	5241- 5324- 5356-	3460-
QUEENSTON FORMATION	5245-	4958-	5234-	3690-	3700-	4058-	5472-	5212-	5368-	
PRODUCING FORMATION	Medina	Medina	Medina	Medina	Medina	Medina	Medina	Medina	Medina	
DEEPEST PRODUCING DEPTH	5126	4861	5229	3635	3645	3985	5466	5152	5318	
TOTAL DEPTH	5316	5076	5385	3763	3783	4140	5596	5258	5445	3460
DEEPEST FORMATION REACHED	Queenston	Queenston	Queenston	Queenston	Queenston	Queenston	Queenston	Queenston	Queenston	Medina
RESULTS	391 Mcf AF 835 psi/48 hrs. development Mt Hope pool Frenchtown field	1500 Mcf AF 1425 psi/48 hrs. development Eastman Hill pool Sparta field	612 Mcf AF 910 psi/48 hrs. development Rome pool Athens field	50 Mcf AF 850 psi/72 hrs. development Indian Springs pool Conneaut field	20 Mcf AF 1100 psi/72 hrs. development Indian Springs pool Conneaut field	100 Mcf AF 1150 psi/72 hrs. development Indian Springs pool Conneaut field	190 Mcf AF 1325 psi/72 hrs. development vrooman pool Chubb Run field	120 Mcf AF 1200 psi/120 hrs. development Mt. Hope pool Frenchtown field	200 Mcf AF 1350 psi/288 hrs. development O'Rand pool Frenchtown field	Junked and abandoned miscellaneous Lundys Lane pool Conneaut field

COUNTY PERMIT NUMBER	Erie 049-21421	Erie 049-21724	Erie 049-22265	Erie 049-22754	Erie 049-23820	Erie 049-24527	Erie 049-24956	Erie 049-24957	Erie 049-24958	Erie 049-24960
NAME OF WELL	Proctor, H. #1	Schaaf, W. & B. #1	Dirienzo #1	Zimmerman #1	Lantz #5	Tomczak, D. #1	Meabon, Ronald #11	Derner, G. #1	Szymanowski, V. #1	Thompson, James #1
OPERATOR	Envirogas, Inc.	Sequoia Management Co., Inc.	Dirienzo, Dominick A.	Kaltas Oil Co., Inc.	U.S. Energy Development Corp.	N.E.A. Cross Co.	ENCX, Inc.	Kidder Exploration, Inc.	Mid American Natural Resources	Mid American Natural Resources
TOWNSHIP	Waterford	Waterford	Summit	Greenfield	Venango	Greene	Venango	Amity	McKean	Venango
QUADRANGLE	Waterford	Cambridge Springs NE	Erie South	Wattsburg	Wattsburg	Hammett	Wattsburg	Union City	Cambridge Springs NE	Hammett
LATITUDE	7,300 ft. S 42°00'00"	14,100 ft. S 41°57'30"	11,500 ft. S 42°05'00"	6,350 ft. S 42°07'30"	9,450 ft. S 42°02'30"	13,390 ft. S 42°05'00"	5,125 ft. S 42°02'30"	4,280 ft. S 42°00'00"	8,950 ft. S 42°00'00"	14,900 ft. S 42°05'00"
LONGITUDE	7,300 ft. W 79°52'30"	2,350 ft. W 80°00'00"	2,500 ft. W 80°00'00"	2,940 ft. W 79°50'00"	7,090 ft. W 79°45'00"	9,000 ft. W 79°57'30"	6,650 ft. W 79°47'30"	10,400 ft. W 79°47'30"	7,950 ft. W 80°02'30"	1,900 ft. W 79°52'30"
DATE COMPLETED	9-17-81	3-3-82	9-1-82	10-11-83	11-28-84	8-6-90	2-6-90	2-15-90	3-1-90	6-28-90
ELEVATION	1530 GR	1370 GR	1320 GR	1440 GR	1409 GR	1440 GR	1300 GR	1330 GR	1440 GR	1475 GR
LOGS RECEIVED AND LOGGED INTERVALS	CDL/GR: 0-4112 DLL/GR: 2104-4104	CDL/CNL: 2600-4134				CDL/DLL: 2100-3878		GR/CDL: 0-4009 DIL: 0-4009	CDL/CNL: 2250-3968 DLL/GR: 2250-3968 INT: 2250-3968	CDL/CNL: 2200-3918
TULLY LIMESTONE	2414-		1814-		2283-	2114-	2247-	2292-	2320-	2272-
ONONDAGA LIMESTONE HUNTERSVILLE CHERT	2634-	2662-	2038-		2523-	2342-	2463-	2520-	2542-	2498-
ORISKANY SANDSTONE RIDGELEY SANDSTONE	2884-					2594-	2644-		2804-	2746-
SILURIAN-DEVONIAN CARBONATES	2894-	2854-			2726-	2604-	2690-	2762-	2825-	2773-
SALINA GROUP LOCKPORT DOLOMITE	2950- 3498-	2988- 3508-			2876-	2696- 3180-		2842- 3384-	2917- 3350-	2826- 3322-
POCHESTER SHALE IRONDEQUOIT DOLOMITE	3768- 3828-	3783- 3844-				3441- 3490-		3637- 3690-	3602- 3657-	3588- 3638-
GRIMSBY FORMATION CAROT HEAD SHALE WHIRLPOOL SANDSTONE	3861- 3947- 4014-	3866- 3986- 4045-		3550- 3590- 3620-		3527- 3632- 3678-		3732- 3836- 3876-	3698- 3780- 3854-	3670- 3790- 3824-
QUEENSTON FORMATION	4022-	4050-		3632-		3684-		3885-	3861-	3830-
PRODUCING FORMATION		Medina		Medina		Oriskany/Medina	Bass Islands		Medina	Medina
DEEPEST PRODUCING DEPTH		4047		3630		3591	2705		3772	3760
TOTAL DEPTH	4114	4135	2117	3712	2909	3800	2798	4009	3968	3918
DEEPEST FORMATION REACHED	Queenston	Queenston	Onondaga	Queenston	Salina	Queenston	Bass Islands	Queenston	Queenston	Queenston
RESULTS	Dry and abandoned development Waterford Lumber field	8204 Mcf AF development Swails Drainin field	Dry and abandoned exploratory (NPW) Unnamed field	IP not reported development Hornby Nor-East field	Dry and abandoned development Macedonia Canfield	100 Mcf AF 700 psi/48 hrs. deepened 1207 ft. development Barcosic/Goddard Erie field	0 Mcf AF 380 psi/48 hrs. development Lowville Nor-East field	Plugged and abandoned development Alder Run field	200 Mcf AF 1010 psi/48 hrs. development Reeds Corners field	300 Mcf AF 1000 psi/48 hrs. development Dennee Phillips field

Figure 47. (Continued).

COUNTY PERMIT NUMBER	Erie 049-24961	Erie 049-24962	Erie 049-24963	Erie 049-24965	Erie 049-24967	Erie 049-24969	Fayette 051-20506	Fayette 051-20521	Indiana 063-29738	Mercer 085-20435
NAME OF WELL	Romba, Raymond #2	Roberts #3	Romba, Raymond #3	Chapman, R. #2	Ware, John #1	Waterhouse, J. #2	Hacker #1-21792	Kreinbrook #1	Schneider, E. #1-D	Titus #1
OPERATOR	N.E.A. Cross Co.	N.E.A. Cross Co.	N.E.A. Cross Co.	N.E.A. Cross Co.	N.E.A. Cross Co.	N.E.A. Cross Co.	Columbia Natural Resources	CMG Producing Company	Energy Production Co.	Atlas Resources, Inc.
TOWNSHIP	Waterford	Waterford	Waterford	Greene	McKean	LeBoeufs	Henry Clay	Bullskin	Buffington	West Salem
QUADRANGLE	Cambridge Springs NE	Cambridge Springs NE	Cambridge Springs NE	Hammett	Erie South	Cambridge Springs	Ohio	Mammoth	Strongstown	Kinsman
LATITUDE	15,300 ft. S 42°00'00"	12,550 ft. S 42°00'00"	14,620 ft. S 42°00'00"	7,980 ft. S 42°02'30"	11,100 ft. S 42°02'30"	4,800 ft. S 41°52'30"	14,400 ft. S 39°52'30"	14,200 ft. S 40°10'00"	1,430 ft. S 40°32'30"	14,150 ft. S 41°02'00"
LONGITUDE	6,180 ft. W 80°02'30"	7,110 ft. W 80°02'30"	6,600 ft. W 80°02'30"	6,190 ft. W 79°55'00"	10,420 ft. W 80°02'30"	50 ft. W 80°00'00"	1,000 ft. W 79°25'00"	8,550 ft. W 79°27'30"	4,850 ft. W 78°55'00"	3,500 ft. W 80°30'00"
DATE COMPLETED	7-3-90	10-22-90	6-28-90	8-15-90	8-20-90	11-7-90	6-9-89	8-2-90	8-23-89	9-9-82
ELEVATION	1445 GR	1455 GR	1440 GR	1400 GR	1325 GR	1210 GR	2510 GR	1504 GR	1961 GR	1174 GR
LOGS RECEIVED AND LOGGED INTERVALS	CDL/DLL: 2339-4011	CDL/DLL: 2297-3998		CDL: 2100-3881	CDL/DLL: 1980-3654 GR/PCL: 3300-3610	CDL/DLL: 2400-4178				
TULLY LIMESTONE	2358-	2352-	2329-	2182-	2028-	2432-		6988-	7580-	
ONONDAGA LIMESTONE	2580-	2572-	2547-	2406-	2250-	2652-	7662- 7681-	7525- 7546-	8352- 8365-	3094-
HUNTERSVILLE CHERT				2654-	2508-	2898-		7697-	8466-	3321-
ORISKANY SANDSTONE								7800-		3331-
RISELEY SANDSTONE										
SILURIAN-DEVONIAN CARBONATES	2820-	2812-		2670-	2526-	2923-			8602-	
SALINA GROUP LOCKPORT DOLOMITE	2992- 3434-	2932- 3380-		2752- 3258-	2614- 3122-	2964- 3514-				3453- 4262-
ROCHESTER SHALE IRONDEQUOIT DOLOMITE	3662- 3720-	3650- 3704-		3524- 3578-	3358- 3414-	3803- 3860-				4558- 4609-
GRIMSBY FORMATION CABOT HEAD SHALE WHIRLPOOL SANDSTONE	3740- 3862- 3906-	3738- 3816- 3894-		3610- 3722- 3766-	3451- 3565- 3602-	3882- 4019- 4060-				4782- 4857-
QUEENSTON FORMATION	3913-	3901-		3776-	3609-	4069-				4868-
PRODUCING FORMATION	Medina	Medina		Medina	Medina	Medina	Huntersville	Ridgeley	Huntersville	
DEEPEST PRODUCING DEPTH	3851	3814		3697	3519	4017	7745	7753	8400	
TOTAL DEPTH	4032	4028	2787	3902	3680	4191	7745	7898	8602	4995
DEEPEST FORMATION REACHED	Queenston	Queenston	Onondaga	Queenston	Queenston	Queenston	Huntersville	Heldenberg	Heldenberg	Queenston
RESULTS	200 Mcf AF 800 psi/48 hrs. development Reeds Corners field	700 Mcf AF 800 psi/48 hrs. development Reeds Corners field	Junked and abandoned miscellaneous Reeds Corners field	800 Mcf AF 1000 psi/48 hrs. development Goddard pool Erie field	500 Mcf AF 900 psi/48 hrs. development Dunn Valley pool Erie field	1000 Mcf AF 700 psi/48 hrs. development Mill Village field	4500 Mcf AF 2700 psi/72 hrs. development Ohio field	6000 Mcf AF 3400 psi/48 hrs. development Bullskin field	495 Mcf AF 3540 psi/40 hrs. development Carne Run pool Nolo field	Dry and abandoned exploratory (EXT) Maysville field

COUNTY PERMIT NUMBER	Mercer 085-21005	Mercer 085-21008	Mercer 085-21009	Mercer 085-21010	Mercer 085-21012	Mercer 085-21013	Mercer 085-21014	Mercer 085-21015	Mercer 085-21016	Mercer 085-21017
NAME OF WELL	Stambaugh #1	Watson Unit #1	Morrison D. & I. #1	Magarice, J. #1	Nickel, R. & M. #2	Sailor, F. & S. #1	Meade, H. & J. #1	Bagnall, H. & A. #1	Jefferson Twp. #1-A	Babinka, P. & L. #1
OPERATOR	Atlas Resources, Inc.	Everflow Eastern, Inc.	Atlas Resources, Inc.	Atlas Resources, Inc.	Atlas Resources, Inc.	Atlas Resources, Inc.	Atlas Resources, Inc.	Atlas Resources, Inc.	Atlas Resources, Inc.	Atlas Resources, Inc.
TOWNSHIP	Jefferson	Jefferson	Jefferson	Jefferson	Jefferson	Jefferson	Jefferson	Jefferson	Jefferson	Jefferson
QUADRANGLE	Greenfield	Sharon East	Fredonia	Fredonia	Fredonia	Fredonia	Fredonia	Fredonia	Greenfield	Fredonia
LATITUDE	4,850 ft. S 4,1015'00"	2,475 ft. S 4,1017'30"	11,150 ft. S 4,1017'30"	12,500 ft. S 4,1017'30"	7,500 ft. S 4,1017'30"	14,650 ft. S 4,1017'30"	11,375 ft. S 4,1017'30"	14,600 ft. S 4,1017'30"	1,450 ft. S 4,1015'00"	8,675 ft. S 4,1017'30"
LONGITUDE	3,100 ft. W 80°20'00"	650 ft. W 80°22'30"	4,975 ft. W 80°20'00"	125 ft. W 80°20'00"	5,525 ft. W 80°20'00"	1,450 ft. W 80°20'00"	175 ft. W 80°20'00"	10,225 ft. W 80°17'30"	10,850 ft. W 80°17'30"	1,825 ft. W 80°20'00"
DATE COMPLETED	3-22-90	3-27-90	1-30-90	2-7-90	2-24-90	2-2-90	1-12-90	2-21-90	2-1-90	1-29-90
ELEVATION	1280 GR	1240 GR	1174 GR	1317 GR	1025 GR	1270 GR	1161 GR	1228 GR	1263 GR	1072 GR
LOGS RECEIVED AND LOGGED INTERVALS	CDL/CNL: 793-5718 DLL/GR: 793-5734	CDL/CNL: 500-5705 PLL: 5250-5648	CDL/CNL: 0-5597 DLL/GR: 622-5615	CDL/CNL: 0-5721 DLL/GR: 0-5721	CDL/CNL: 0-5398 DLL/GR: 593-5407	CDL/CNL: 0-5661 DLL/GR: 720-5661	CDL/CNL: 0-5526 DLL/GR: 604-5526 INT: 5258-5500	CDL/CNL: 0-5648 DLL/GR: 709-5648	CDL/CNL: 0-5720 DLL/GR: 836-5720	CDL/CNL: 0-5435 DLL/GR: 510-5435 INT: 5150-5404
TULLY LIMESTONE	3652-		3456-	3638-	3300-	3604-	3474-	3572-	3634-	3358-
ONONDAGA LIMESTONE HUNTERSVILLE CHERT	3786-	3662-	3596-	3777-	3440-	3742-	3614-	3710-	3770-	3500-
ORISKANY SANDSTONE RIDGELEY SANDSTONE	3952-	3832-	3759-	3940-	3596-	3904-	3781-	3871-	3930-	3667-
SILURIAN-DEVONIAN CARBONATES	3978-	3857-	3782-	3964-	3626-	3930-	3803-	3896-	3956-	3692-
SALINA GROUP LOCKPORT DOLOMITE	4138- 5008-	4016- 4908-	3936- 4819-	4118- 4996-	3776- 4658-	4082- 4968-	3952- 4840-	4050- 4984-	4112- 5022-	3842- 4712-
ROCHESTER SHALE IRONDEQUOIT DOLOMITE	5304- 5368-	5201- 5261-	5122- 5182-	5298- 5358-	4950- 5006-	5232- 5323-	5126- 5186-	5234- 5298-	5291- 5354-	5016- 5074-
GRIMSBY FORMATION CAROT HEAD SHALE WHIRLPOOL SANDSTONE	5453- 5270- 5658-	5335- 5528-	5256- 5376- 5398-	5432- 5556- 5628-	5078- 5200- 5274-	5398- 5520- 5592-	5260- 5380- 5454-	5374- 5494- 5564-	5431- 5552- 5624-	5149- 5270- 5344-
QUEENSTON FORMATION	5651-	5540-	5406-	5640-	5282-	5604-	5466-	5578-	5636-	5351-
PRODUCING FORMATION	Medina	Medina	Medina	Medina	Medina	Medina	Medina	Medina	Medina	Medina
DEEPEST PRODUCING DEPTH	5649	5454	5463	5538	5280	5603	5463	5578	5635	5349
TOTAL DEPTH	5770	5719	5630	5740	5440	5719	5563	5700	5770	5470
DEEPEST FORMATION REACHED	Queenston	Queenston	Queenston	Queenston	Queenston	Queenston	Queenston	Queenston	Queenston	Queenston
RESULTS	1390 Mcf AF 1525 psi/48 hrs. development Greenfield field	350 Mcf AF 1400 psi/24 hrs. development Sharon Deep field	730 Mcf AF 1275 psi/48 hrs. development Sharon Deep field	1360 Mcf AF 1520 psi/48 hrs. development Greenfield field	980 Mcf AF 1400 psi/48 hrs. development Sharon Deep field	1020 Mcf AF 1480 psi/48 hrs. development Greenfield field	1100 Mcf AF 1525 psi/48 hrs. development Greenfield field	1000 Mcf AF 1500 psi/48 hrs. development Greenfield field	750 Mcf AF 1320 psi/48 hrs. development Greenfield field	1180 Mcf AF 1500 psi/48 hrs. development Sharon Deep pool Sharon field

Figure 47. (Continued).

COUNTY PERMIT NUMBER	Mercer 085-21018	Mercer 085-21019	Mercer 085-21021	Mercer 085-21022	Mercer 085-21023	Mercer 085-21025	Mercer 085-21027	Mercer 085-21028	Mercer 085-21029	Mercer 085-21031
NAME OF WELL	McCullough Unit #7	O'Shany, M. Unit #1	Jewell, C. #3	Babnis, O. & E. #2	Niezgoda, F. #1	Bukus #1	Jewell, R. #2	McWilliams #2	Angermeier #1	Dermond, H. & R. #1
OPERATOR	Atlas Resources, Inc.	Atlas Resources, Inc.	Atlas Resources, Inc.	Atlas Resources, Inc.	Atlas Resources, Inc.	Atlas Resources, Inc.	Atlas Resources, Inc.	Atlas Resources, Inc.	Atlas Resources, Inc.	Atlas Resources, Inc.
TOWNSHIP	Jefferson	Jefferson	Jefferson	Jefferson	Jefferson	Jefferson	Jefferson	Jefferson	Jefferson	Lackawamock
QUADRANGLE	Fredonia	Fredonia	Fredonia	Fredonia	Fredonia	Fredonia	Fredonia	Fredonia	Fredonia	Sharon East
LATITUDE	12,050 ft. S 4,101'7"30"	9,500 ft. S 4,101'7"30"	10,450 ft. S 4,101'7"30"	12,525 ft. S 4,101'7"30"	12,475 ft. S 4,101'7"30"	7,275 ft. S 4,101'7"30"	14,900 ft. S 4,101'7"30"	14,700 ft. S 4,101'7"30"	7,900 ft. S 4,101'7"30"	6,775 ft. S 4,101'5"00"
LONGITUDE	6,375 ft. W 80°20'00"	3,650 ft. W 80°20'00"	1,650 ft. W 80°20'00"	7,425 ft. W 80°17'30"	5,675 ft. W 80°17'30"	3,800 ft. W 80°20'00"	5,725 ft. W 80°20'00"	7,450 ft. W 80°17'30"	200 ft. W 80°20'00"	2,400 ft. W 80°22'30"
DATE COMPLETED	1-17-90	2-14-90	2-7-90	3-2-90	2-13-90	2-24-90	4-11-90	2-23-90	1-30-90	2-14-90
ELEVATION	1214 GR	1062 GR	1085 GR	1292 GR	1294 GR	1997 GR	1207 GR	1262 GR	1168 GR	1154 GR
LOGS RECEIVED AND LOGGED INTERVALS	COL/CNL: 0-5573 OLL/GR: 656-5573 INT: 5300-5540	COL/CNL: 0-5435 OLL/GR: 557-5435	COL/CNL: 0-5508 OLL/GR: 0-5508	COL/CNL: 0-5702 OLL/GR: 811-5702	COL/CNL: 0-5726 OLL/GR: 0-5726	COL/CNL: 0-4435 OLL/GR: 0-4435	COL/CNL: 0-5614 OLL/GR: 647-5614 INT: 5320-5575	COL/CNL: 0-5703 OLL/GR: 754-5722	COL/CNL: 0-5518 OLL/GR: 636-5536	COL/CNL: 0-5358 OLL/GR: 0-5358 CBL/PCL: 4500-5573
TULLY LIMESTONE	3499-	3350-	3384-	3638-	3644-	3282-	3524-	3626-	3457-	3484-
ONONDAGA LIMESTONE HUNTERSVILLE CHERT	3636-	3490-	3524-	3738-	3786-	3422-	3660-	3764-	3600-	3618-
ORISKANY SANDSTONE RIDGELEY SANDSTONE	3800-	3656-	3692-	3938-	3946-	3592-	3828-	3922-	3768-	3791-
SILURIAN-DEVONIAN CARBONATES	3824-	3678-	3714-	3962-	3971-	3616-	3853-	3936-	3793-	3816-
SALINA GROUP LOCKPORT DOLOMITE	3978- 4892-	3828- 4718-	3864- 4740-	4114- 5002-	4126- 5002-	3768- 4642-	4008- 4896-	4106- 4988-	3944- 4803-	3978- 4844-
ROCHESTER SHALE IRONDEQUOIT DOLOMITE	5168- 5227-	5008- 5068-	5040- 5100-	5301- 5362-	5302- 5364-	4934- 4990-	5186- 5248-	5257- 5347-	5106- 5166-	5154- 5213-
GRIMSBY FORMATION CARBOT HEAD SHALE WHIRLPOOL SANDSTONE	5302- 5424- 5496-	5141- 5266- 5336-	5175- 5297- 5368-	5440- 5526- 5630-	5442- 5561- 5630-	5062- 5320- 5536-	5325- 5561- 5522-	5425- 5542- 5616-	5240- 5362- 5433-	5290- 5401- 5486-
QUEENSTON FORMATION	5508-	5348-	5378-	5644-	5645-	5268-	5528-	5630-	5444-	5493-
PRODUCING FORMATION	Medina	Medina	Medina	Medina	Medina	Medina	Medina	Medina	Medina	Medina
DEEPEST PRODUCING DEPTH	5506	5347	5377	5642	5642	5267	5447	5628	5442	3593
TOTAL DEPTH	5622	5475	5531	5746	5757	5365	5655	5765	5561	5600
DEEPEST FORMATION REACHED	Queenston	Queenston	Queenston	Queenston	Queenston	Queenston	Queenston	Queenston	Queenston	Queenston
RESULTS	980 Mcf AF 1425 psi/48 hrs. development Sharon Deep pool Sharon field	1150 Mcf AF 1500 psi/48 hrs. development Sharon Deep pool Sharon field	1280 Mcf AF 1500 psi/48 hrs. development Sharon Deep pool Sharon field	1000 Mcf AF 1450 psi/48 hrs. development Greenfield field	1000 Mcf AF 1450 psi/48 hrs. development Greenfield field	1020 Mcf AF 1400 psi/48 hrs. development Sharon Deep pool Sharon field	1000 Mcf AF 1450 psi/48 hrs. development Sharon Deep pool Sharon field	1000 Mcf AF 1450 psi/48 hrs. development Sharon Deep pool Sharon field	IP not reported development Greenfield field	1000 Mcf AF 1500 psi/48 hrs. development Greenfield field

COUNTY PERMIT NUMBER	Mercer 085-21032	Mercer 085-21033	Mercer 085-21035	Mercer 085-21038	Mercer 085-21043	Mercer 085-21046	Mercer 085-21047	Mercer 085-21049	Mercer 085-21052	Mercer 085-21053
NAME OF WELL	Steingrabe Unit #1	Romain, J. #2	Jewel, J. #5	Stambaugh, M. #5	Stambaugh, M. #3	Cupic, W. & S. #1	Watson, E. I. #2	Humes Unit #1	Besco #1	Crook Unit #1
OPERATOR	Atlas Resources, Inc.	Everflow Eastern, Inc.	Atlas Resources, Inc.	Atlas Resources, Inc.	Atlas Resources, Inc.	Atlas Resources, Inc.	Everflow Eastern, Inc.	Atlas Resources, Inc.	Atlas Resources, Inc.	Atlas Resources, Inc.
TOWNSHIP	Jefferson	Jefferson	Jefferson	Jefferson	Jefferson	Jefferson	Jefferson	Jefferson	Jefferson	Jefferson
QUADRANGLE	Fredonia	Sharon East	Greenfield	Fredonia	Fredonia	Fredonia	Sharon East	Fredonia	Fredonia	Fredonia
LATITUDE	14,550 ft. S 41°17'30"	825 ft. S 41°15'00"	1,425 ft. S 41°15'00"	10,650 ft. S 41°17'30"	7,750 ft. S 41°17'30"	9,450 ft. S 41°17'30"	700 ft. S 41°15'00"	11,050 ft. S 41°17'30"	12,700 ft. S 41°17'30"	13,250 ft. S 41°17'30"
LONGITUDE	3,900 ft. W 80°17'30"	10,575 ft. W 80°20'00"	1,100 ft. W 80°20'00"	9,925 ft. W 80°17'30"	10,025 ft. W 80°17'30"	675 ft. W 80°17'30"	700 ft. W 80°22'30"	11,325 ft. W 80°15'00"	3,950 ft. W 80°17'30"	250 ft. W 80°17'30"
DATE COMPLETED	4-19-90	3-24-90	2-16-90	2-21-90	2-22-90	3-22-90	3-28-90	3-29-90	3-7-90	4-19-90
ELEVATION	1018 GR	1212 GR	1281 GR	1184 GR	1182 GR	1155 GR	1170 GR	1165 GR	1063 GR	1092 GR
LOGS RECEIVED AND LOGGED INTERVALS	CDL/CNL: 0-5501 DLL/GR: 0-5501 INT: 0-5501	CDL/CNL: 500-5638 PCL: 5250-5620	CDL/CNL: 0-5713 DLL/GR: 774-5713	CDL/CNL: 0-5587 DLL/GR: 650-5587	CDL/CNL: 0-5529 DLL/GR: 622-5548	DLL/GR: 0-5604	CDL/CNL: 3550-5598 PCL: 5250-5570	CDL/CNL: 0-5659 DLL/GR: 666-5659	CDL/CNL: 0-5491 DLL/GR: 621-5510 INT: 5290-5560	CDL/CNL: 0-5564 DLL/GR: 621-5564 INT: 5290-5560
TULLY LIMESTONE	3408-		3640-	3498-	3476-	3524-		3560-	3428-	3492-
ONONDAGA LIMESTONE HUNTERSVILLE CHERT	3550-	3634-	3778-	3640-	3616-	3666-		3702-	3568-	3634-
OREGANY SANDSTONE RIDGELEY SANDSTONE	3712-	3800-	3940-	3806-	3783-	3829-	3780-	3863-	3726-	3794-
SILURIAN-DEVONIAN CARBONATES	3728-	3824-	3966-	3828-	3810-	3856-	3796-	3886-	3757-	3818-
SALINA GROUP LOCKPORT DOLOMITE	3886- 4774-	3982- 4870-	4120- 4995-	3978- 4854-	3960- 4824-	4004- 4887-	3954- 4836-	4040- 4922-	3904- 4786-	3972- 4882-
ROCHESTER SHALE IRONDEQUOIT DOLOMITE	5066- 5126-	5175- 5234-	5294- 5356-	5154- 5216-	5128- 5188-	5186- 5246-	5142- 5203-	5216- 5278-	5084- 5146-	5152- 5214-
GRIMSBY FORMATION CAROT HEAD SHALE WHIRPOOL SANDSTONE	5208- 5328- 5392-	5310- 5435- 5504-	5432- 5554- 5627-	5290- 5412- 5483-	5262- 5385- 5455-	5327- 5442- 5512-	5278- 5402- 5472-	5356- 5474- 5546-	5224- 5336- 5412-	5291- 5436- 5480-
QUEENSTON FORMATION	5410-	5516-	5638-	5494-	5464-	5522-	5486-	5562-	5428-	5496-
PRODUCING FORMATION	Medina	Medina	Medina	Medina	Medina	Medina	Medina	Medina	Medina	Medina
DEEPEST PRODUCING DEPTH	5401	5434	5637	5492	5461	5522	5402	5504	5427	5432
TOTAL DEPTH	5533	5646	5770	5624	5552	5630	5607	5692	5550	5579
DEEPEST FORMATION REACHED	Queenston	Queenston	Queenston	Queenston	Queenston	Queenston	Queenston	Queenston	Queenston	Queenston
RESULTS	1000 Mcf AF 1525 psi/48 hrs. development Greenfield field	350 Mcf AF 1450 psi/24 hrs. development Sharon Deep pool Sharon field	1050 Mcf AF 1425 psi/48 hrs. development Greenfield field	1210 Mcf AF 1520 psi/48 hrs. development Greenfield field	1080 Mcf AF 1500 psi/48 hrs. development Greenfield field	1090 Mcf AF 1350 psi/48 hrs. exploratory Lackawanna pool Big Bend field	1220 Mcf AF 1550 psi/48 hrs. development Lackawanna pool Big Bend field	1200 Mcf AF 1450 psi/48 hrs. development Greenfield field	1000 Mcf AF 1525 psi/48 hrs. development Greenfield field	

Figure 47. (Continued).

COUNTY PERMIT NUMBER	Mercer 085-21054	Mercer 085-21056	Mercer 085-21058	Mercer 085-21060	Mercer 085-21061	Mercer 085-21062	Mercer 085-21063	Mercer 085-21064	Mercer 085-21065	Mercer 085-21067
NAME OF WELL	Burrows Unit #1-074	Yambrovich #1-004	Besco #2	Bungar Unit #1	Lubecki Unit #2	Furey Unit #1	Meredith Unit #1	Eli Unit #1	Canon Unit #2	Rea Unit #2
OPERATOR	Atwood Energy, Inc.	Atwood Energy, Inc.	Atlas Resources, Inc.	Atwood Energy, Inc.	Atwood Energy, Inc.	Atwood Energy, Inc.	Atwood Energy, Inc.	Atwood Energy, Inc.	Atwood Energy, Inc.	Atwood Energy, Inc.
TOWNSHIP	Shenango	South Pymatuning	Jefferson	Shenango	Shenango	Shenango	Shenango	Shenango	Shenango	Shenango
QUADRANGLE	Sharon West	Sharpsville	Fredonia	Sharon West	Sharon East	Sharon East	Sharon East	Sharon East	Sharon East	Sharon East
LATITUDE	6,800 ft. S 4,101'00"	5,150 ft. S 4,102'00"	10,675 ft. S 4,107'30"	9,800 ft. S 4,101'00"	5,600 ft. S 4,101'00"	500 ft. S 4,101'00"	9,200 ft. S 4,101'00"	6,700 ft. S 4,101'00"	8,900 ft. S 4,101'00"	2,900 ft. S 4,101'00"
LONGITUDE	2,250 ft. W 80°30'00"	10,600 ft. W 80°27'30"	3,850 ft. W 80°17'30"	2,150 ft. W 80°30'00"	7,100 ft. W 80°27'30"	9,500 ft. W 80°27'30"	4,550 ft. W 80°27'30"	10,200 ft. W 80°27'30"	7,650 ft. W 80°27'30"	5,800 ft. W 80°27'30"
DATE COMPLETED	3-16-90	4-6-90	4-10-90	6-12-90	8-7-90	6-19-90	7-16-90	10-31-90	7-2-90	6-22-90
ELEVATION	1110 GR	970 GR	972 GR	957 GR	1073 GR	1049 GR	1055 GR	1105 GR	1073 GR	1133 GR
LOGS RECEIVED AND LOGGED INTERVALS	COL/GR: 400-5541		COL/CNL: 606-5380 OLL/GR: 606-5395 INT: 606-5395	COL/GR: 450-5479	COL/GR: 400-5592	COL/GR: 50-5539	GR/COL: 300-5580	COL/GR: 450-5616		COL/GR: 500-5640
TULLY LIMESTONE			3318-							
ONONDAGA LIMESTONE HUNTERSVILLE CHERT	3514-	3040-	3458-	3406-	3548-	3494-	3582-	3570-	3565-	3608-
ORISKANY SANDSTONE RIDGELEY SANDSTONE		3286-	3620-						3746-	
SILURIAN-DEVONIAN CARBONATES	3716-	3295-	3646-		3799-	3691-	3768-	3820-	3761-	3877-
SALINA GROUP LOCKPORT DOLOMITE	3918- 4806-	3398- 4244-	3796- 4678-	3810- 4700-	3937- 4834-	3886- 4752-	3972- 4874-	3960- 4844-	4044- 4842-	3997- 4888-
ROCHESTER SHALE IRONDEQUOIT DOLOMITE	5122- 5184-	4544- 4599-	4971- 5035-	5018- 5080-	5152- 5217-	5074- 5138-	5181- 5248-	5163- 5226-	5111- 5275-	5194- 5258-
GRIMSBY FORMATION CABOT HEAD SHALE WHIRLPOOL SANDSTONE	5266- 5478- 5467-	4666- 4778- 4854-	5112- 5230- 5302-	5164- 5239- 5364-	5299- 5223- 5500-	5220- 5270- 5416-	5334- 5274- 5528-	5310- 5464- 5508-	5341- 5426- 5512-	5342- 5464- 5540-
QUEENSTON FORMATION	5476-	4866-	5312-	5376-	5508-	5430-	5542-	5517-	5523-	5554-
PRODUCING FORMATION	Medina	Medina	Medina	Medina	Medina	Medina	Medina	Medina	Medina	Medina
DEEPEST PRODUCING DEPTH	5474	4866	5310	5373	5506	5425	5538	5513	5522	5554
TOTAL DEPTH	5546	4970	5425	5377	5720	5540	5610	5624	5610	5638
DEEPEST FORMATION REACHED	Queenston	Queenston	Queenston	Queenston	Queenston	Queenston	Queenston	Queenston	Queenston	Queenston
RESULTS	97 Mcf AF 1405 psi/48 hrs. development wheatland field	105 Mcf AF 1275 psi/24 hrs. development Sharon Deep pool Sharon field	1000 Mcf AF 1500 psi/48 hrs. development Greenfield field	78 Mcf AF 1310 psi/72 hrs. development wheatland field	80 Mcf AF 1230 psi/72 hrs. development wheatland field	116 Mcf AF 1305 psi/192 hrs. development wheatland field	92 Mcf AF 1395 psi/72 hrs. development wheatland field	70 Mcf AF 1050 psi/96 hrs. development wheatland field	55 Mcf AF 1290 psi/72 hrs. development wheatland field	97 Mcf AF 1275 psi/72 hrs. development wheatland field

COUNTY PERMIT NUMBER	Mercer 085-21068	Mercer 085-21069	Mercer 085-21070	Mercer 085-21071	Mercer 085-21072	Mercer 085-21073	Mercer 085-21074	Mercer 085-21075	Mercer 085-21076	Mercer 085-21078
NAME OF WELL	Pajank Unit #1	Carpec Unit #1	Canon Unit #1	Allen Unit #1	Ryser Unit #3	Antoun, A. #1	Sweet, Harry #1	Abmayr, J. #1	Clarke Unit #4	Burrows Unit #2
OPERATOR	Atwood Energy, Inc.	Atwood Energy, Inc.	Atwood Energy, Inc.	Atwood Energy, Inc.	Atwood Energy, Inc.	Cabot Oil & Gas Corp.	Cabot Oil & Gas Corp.	Cabot Oil & Gas Corp.	Atwood Energy, Inc.	Atwood Energy, Inc.
TOWNSHIP	Shenango	Shenango	Shenango	Shenango	Shenango	French Creek	French Creek	French Creek	Shenango	Shenango
QUADRANGLE	Sharon East	Sharon East	Sharon East	Sharon East	Sharon West	New Lebanon	New Lebanon	New Lebanon	Sharon East	Sharon West
LATITUDE	6,900 ft. S 41°10'00"	2,500 ft. S 41°10'00"	7,400 ft. S 41°10'00"	6,400 ft. S 41°10'00"	5,900 ft. S 41°10'00"	1,050 ft. S 41°02'30"	5,750 ft. S 41°02'30"	7,880 ft. S 41°02'30"	10,800 ft. S 41°10'00"	7,900 ft. S 41°10'00"
LONGITUDE	3,100 ft. W 80°27'30"	9,200 ft. W 80°27'30"	7,350 ft. W 80°27'30"	250 ft. W 80°27'30"	600 ft. W 80°30'00"	3,900 ft. W 80°02'30"	6,500 ft. W 80°02'30"	2,980 ft. W 80°02'30"	5,600 ft. W 80°27'30"	4,350 ft. W 80°30'00"
DATE COMPLETED	7-20-90	11-8-90	7-30-90	7-19-90	8-30-90	7-27-90	8-18-90	8-1-90	7-11-90	11-29-90
ELEVATION	1132 GR	1072 GR	1067 GR	1125 GR	1115 GR	1190 GR	1365 GR	1367 GR	1028 GR	948 GR
LOGS RECEIVED AND LOGGED INTERVALS	CDL/GR: 530-5681	GR/CDL: 400-5565	GR/CDL: 450-5597		CDL: 500-5636					CDL: 300-5387 T: 5070-5378
TULLY LIMESTONE						3427-	3630-	3650-		
ONONDAGA LIMESTONE HUNTERSVILLE CHERT	3660-	3510-	3556-	3662-	3556-	3630-	3825-	3846-	3547-	3375-
ORISKANY SANDSTONE RIDGELEY SANDSTONE				3840-		3776-	3975-	3993-	3736-	
SILURIAN-DEVONIAN CARBONATES	3895-	3785-	3820-	3859-	3834-	3800-	4006-	4023-	3802-	3636-
SALINA GROUP LOCKPORT DOLOMITE	4038- 4934-	3902- 4778-	3942- 4830-	4134- 4937-	3954- 4842-	4144- 4600-	4335- 4806-	4314- 4833-	4040- 4831-	3778- 4640-
ROCHESTER SHALE FRONDEQUOIT DOLOMITE	5254- 5322-	5100- 5162-	5160- 5221-	5210-	5160- 5224-	4962- 5073-	5176- 5250-	5212- 5274-	5120-	4986- 5048-
GRIMSBY FORMATION CABOT HEAD SHALE WHIRLPOOL SANDSTONE	5408- 5534- 5606-	5244- 5368- 5440-	5305- 5455- 5502-	5430- 5518- 5598-	5304- 5430- 5503-	5097- 5245- 5283-	5309- 5452- 5483-	5332- 5479- 5516-	5330- 5412- 5501-	5131- 5280- 5332-
QUEENSTON FORMATION	5614-	5456-	5514-	5610-	5515-	5295-	5496-	5532-	5514-	5344-
PRODUCING FORMATION	Medina	Medina	Medina	Medina	Medina	Medina	Medina	Medina	Medina	Medina
DEEPEST PRODUCING DEPTH	5613	5452	5507	5607	5513	5182	5490	5525	5513	5342
TOTAL DEPTH	5690	5576	5606	5720	5627	5418	5609	5636	5580	5389
DEEPEST FORMATION REACHED	Queenston	Queenston	Queenston	Queenston	Queenston	Queenston	Queenston	Queenston	Queenston	Queenston
RESULTS	88 Mcf AF 1325 psi/72 hrs. development Wheatland field	60 Mcf AF 900 psi/96 hrs. development Wheatland field	84 Mcf AF 1355 psi/72 hrs. development Wheatland field	85 Mcf AF 1215 psi/72 hrs. development Wheatland field	65 Mcf AF 800 psi/120 hrs. development Wheatland field	220 Mcf AF 1160 psi/48 hrs. development Kantz Corners field	263 Mcf AF 990 psi/48 hrs. development Kantz Corners field	304 Mcf AF 1350 psi/48 hrs. development Kantz Corners field	85 Mcf AF 1410 psi/72 hrs. development Wheatland field	55 Mcf AF 1100 psi/120 hrs development Wheatland field

Figure 47. (Continued).

COUNTY PERMIT NUMBER	Mercer 085-21082	Mercer 085-21087	Mercer 085-21089	Mercer 085-21091	Mercer 085-21099	Mercer 085-21103	Mercer 085-21104	Mercer 085-21107	Mercer 085-21108	Mercer 085-21109
NAME OF WELL	Habarka #1	Colton, Grant #1	Gorden, Floyd #2	Campgrounds Unit #1	Burns Unit #2	O'Mara Unit #2	Redfoot #1	Hughes Unit #3	Besco, J. & N. #3	Weaver, M. #1
OPERATOR	Capital Oil & Gas, Inc.	Cabot Oil & Gas Corp.	Cabot Oil & Gas Corp.	Atwood Energy, Inc.	Atlas Resources, Inc.	Atlas Resources, Inc.	Atlas Resources, Inc.	Atwood Energy, Inc.	Atlas Resources, Inc.	Atlas Resources, Inc.
TOWNSHIP	Shenango	New Lebanon	New Lebanon	Shenango	Coolspring	Jefferson	Jefferson	Shenango	Jefferson	Jefferson
QUADRANGLE	Sharon West	New Lebanon	New Lebanon	Sharon East	Fredonia	Fredonia	Fredonia	Sharon East	Fredonia	Fredonia
LATITUDE	9,185 ft. S 4,101'27"30"	12,170 ft. S 4,102'27"30"	10,540 ft. S 4,102'27"30"	7,800 ft. S 4,101'00"00"	12,775 ft. S 4,102'00"00"	7,400 ft. S 4,101'17"30"	4,225 ft. S 4,101'17"30"	8,200 ft. S 4,101'00"00"	9,750 ft. S 4,101'17"30"	5,600 ft. S 4,101'17"30"
LONGITUDE	3,000 ft. W 80°30'00"00"	280 ft. W 80°05'00"00"	8,200 ft. W 80°02'30"00"	10,700 ft. W 80°25'00"00"	2,175 ft. W 80°15'00"00"	9,000 ft. W 80°15'00"00"	6,500 ft. W 80°15'00"00"	8,000 ft. W 80°27'30"00"	2,450 ft. W 80°17'30"00"	4,025 ft. W 80°15'00"00"
DATE COMPLETED	11-1-90	9-29-90	8-30-90	11-7-90	11-7-90	10-17-90	10-2-90	11-26-90	9-25-90	11-5-90
ELEVATION	1010 GR	1371 GR	1441 GR	934 GR	1319 GR	1252 GR	1320 GR	1085 GR	987 GR	1312 GR
LOGS RECEIVED AND LOGGED INTERVALS	CNL/GR: 50-5337 W: 3500-5337 PCL: 5000-5304			GR/COL: 300-5528	COL/CNL: 745-5704 OLL: 745-5722	COL/CNL: 703-5690 OLL: 703-5708	COL/CNL: 799-5734 OLL: 799-5751	GR/COL: 380-5598	COL/CNL: 522-5394 DLL: 533-5411	COL/CNL: 755-5770 OLL: 755-5788
TULLY LIMESTONE			3730-		3638-	3626-	3682-		3344-	3700-
ONONDAGA LIMESTONE HUNTERSVILLE CHERT		3836-	3920-	3476-	3788-	3770-	3829-	3572-	3480-	3844-
ORISKANY SANDSTONE RIDGELEY SANDSTONE		3990-	4070-		3942-	3928-	3988-		3646-	4000-
SILURIAN-DEVONIAN CARBONATES		4023-	4102-	3742-	3968-	3954-	4015-	3840-	3673-	4026-
SALINA GROUP LOCKPORT DOLOMITE		4358- 4834-	4439- 4911-	3862- 4752-	4112- 5024-	4104- 5012-	4166- 5040-	3950- 4848-	3822- 4700-	4176- 5054-
ROCHESTER SHALE IRONDEQUOIT DOLOMITE		5201- 5306-	5260- 5366-	5082- 5147-	5294- 5360-	5284- 5343-	5333- 5386-	5173- 5232-	5000- 5066-	5361- 5420-
GRIMSBY FORMATION CAROT HEAD SHALE WHIRLPOOL SANDSTONE		5332- 5485- 5519-	5410- 5558- 5590-	5234- 5334- 5430-	5430- 5550- 5616-	5420- 5568- 5610-	5471- 5623- 5664-	5315- 5440- 5514-	5138- 5257- 5330-	5490- 5645- 5682-
QUEENSTON FORMATION		5527-	5670-	5441-	5630-	5622-	5678-	5526-	5335-	5694-
PRODUCING FORMATION	Medina	Medina	Medina	Medina	Medina	Medina	Medina	Medina	Medina	Medina
DEEPEST PRODUCING DEPTH	5263	5429	5600	5340	5628	5620	5675	5525	5336	5692
TOTAL DEPTH	5368	5643	5728	5534	5739	5725	5768	5603	5427	5805
DEEPEST FORMATION REACHED	Queenston	Queenston	Queenston	Queenston	Queenston	Queenston	Queenston	Queenston	Queenston	Queenston
RESULTS	2300 Mcf AF 1450 psi/72 hrs. development wheatland field	345 Mcf AF 1280 psi/48 hrs. development Kantz Corners field	259 Mcf AF 1410 psi/48 hrs. development Kantz Corners field	IP not reported 200 psi/288 hrs. development wheatland field	650 Mcf AF 1150 psi/48 hrs. development Lackawanna pool Big Bend field	1140 Mcf AF 1450 psi/48 hrs. development Lackawanna pool Big Bend field	980 Mcf AF 1300 psi/48 hrs. development Lackawanna pool Big Bend field	60 Mcf AF 1400 psi/120 hrs. development wheatland field	1180 Mcf AF 1400 psi/48 hrs. development Lackawanna pool Big Bend field	1130 Mcf AF 1500 psi/48 hrs. development Lackawanna pool Big Bend field

SUMMARIZED RECORDS OF DEEP WELLS

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COUNTY PERMIT NUMBER	Mercer 085-21110	Mercer 085-21114	Mercer 085-21116	Mercer 085-21120	Mercer 085-21127	Potter 105-21036	Potter 105-21038	Potter 105-21039	Potter 105-21040	Potter 105-21041
NAME OF WELL	Kish, L. & M. #2	Bagnall Unit #3	Hogan, J. & M. #2	Burke, T. & K. #1	Sunderlin, J. #2	Tract 16 #RW-49	Tract 16 #RW-502	Tract 16 #RW-504	Tract 58 #RW-600	Tract 67 #RW-76
OPERATOR	Atlas Resources, Inc.	Atlas Resources, Inc.	Atlas Resources, Inc.	Capital Oil & Gas, Inc.	Atlas Resources, Inc.	CNG Transmission Corp.	CNG Transmission Corp.	CNG Transmission Corp.	CNG Transmission Corp.	CNG Transmission Corp.
TOWNSHIP	Jefferson	Jefferson	Jefferson	Springfield	Jefferson	Stewardson	Stewardson	Stewardson	Stewardson	Stewardson
QUADRANGLE	Fredonia	Fredonia	Fredonia	Mercer	Fredonia	Young Womans Creek	Young Womans Creek	Oleona	Oleona	Oleona
LATITUDE	9,550 ft. S 4,191'7"30"	14,400 ft. S 4,192'0"00"	14,575 ft. S 4,192'0"00"	5,225 ft. S 4,191'0"00"	14,050 ft. S 4,192'0"00"	8,050 ft. S 4,193'0"00"	3,100 ft. S 4,193'0"00"	14,520 ft. S 4,193'2"30"	10,000 ft. S 4,193'2"30"	7,600 ft. S 4,193'2"30"
LONGITUDE	7,800 ft. W 80°15'10"	3,700 ft. W 80°17'30"	4,650 ft. W 80°15'10"	9,275 ft. W 80°12'30"	8,550 ft. W 80°15'10"	6,300 ft. W 77°42'30"	2,850 ft. W 77°42'30"	10,660 ft. W 77°40'00"	4,290 ft. W 77°40'00"	1,650 ft. W 77°40'00"
DATE COMPLETED	10-29-90	10-23-90	10-10-90	11-15-90	10-31-90	9-26-89	9-21-89	9-21-89	9-22-89	9-23-89
ELEVATION	1273 GR	1073 GR	1313 GR	1197 GR	1292 GR	1706 GR	1688 GR	1759 GR	1927 GR	1880 GR
LOGS RECEIVED AND LOGGED INTERVALS	CDL/CNL: 0-5777 DLL: 885-5777	CDL/CNL: 0-5416 GR/DLL: 0-5416	CDL/CNL: 0-5660 DLL: 0-5660	CNL/GR: 50-6046 T: 3800-6046 PCL: 5750-6068	CDL/CNL: 0-5666 DLL: 618-5666	CNL/CDL: 0-6757 DLL: 1272-6757 CBL/VOL: 100-6692 PCL: 6604-6619	CDL/CNL: 1116-6631 DLL: 1116-6647 CBL/VOL: 0-6568 PCL: 6467-6498	CDL/CNL: 1168-6650 DLL/GR: 1168-6650 CBL/VOL: 0-6565 INT: 6400-6600	CDL/CNL: 1277-6800 DLL/GR: 1277-6816 CBL/VOL: 0-6765 INT: 6634-6638	CDL/CNL: 1222-6826 DLL/GR: 1222-6842 CBL/VOL: 0-6768 PCL: 6665-6670
TULLY LIMESTONE	3674-	3332-	3624-	3960-	3583-	5729-	5606-	5625-	5760-	5739-
ONONDAGA LIMESTONE HUNTERSVILLE CHERT	3818-	3478-	3774-	4111-	3733-	6584-	6444-	6458-	6606-	6636-
ORISKANY SANDSTONE RIDGELEY SANDSTONE	3973-	3642-	3932-	4282-	3892-	6603-	6466-	6480-	6628-	6654-
SILURIAN-DEVONIAN CARBONATES	4000-	3667-	3956-	4302-	3912-	6642-	6504-	6520-	6668-	6690-
SALINA GROUP LOCKPORT DOLOMITE	4152- 5028-	3816- 4687-	4100- 4974-	4456- 5354-	4058- 4942-					
ROCHESTER SHALE IRONDEQUOIT DOLOMITE	5324- 5384-	4090- 5049-	5270- 5338-	5454- 5729-	5240- 5300-					
GRIMSBY FORMATION CAROT HEAD SHALE WHIRLPOOL SANDSTONE	5462- 5618- 5656-	5123- 5263- 5312-	5414- 5569- 5609-	5823- 5977- 6010-	5376- 5524- 5567-					
QUEENSTON FORMATION	5672-	5325-	5616-	6026-	5577-					
PRODUCING FORMATION	Medina	Medina	Medina	Medina	Medina	Ridgeley	Ridgeley	Ridgeley	Ridgeley	Ridgeley
DEEPEST PRODUCING DEPTH	5617	5323	5563	6025	5484					
TOTAL DEPTH	5790	5446	5686	6108	5710	6780	6665	6670	6838	6875
DEEPEST FORMATION REACHED	Queenston	Queenston	Queenston	Queenston	Queenston	Helderberg	Helderberg	Helderberg	Helderberg	Helderberg
RESULTS	1220 Mcf AF 1440 psi/48 hrs. development pool Big Bend field	750 Mcf AF 1250 psi/48 hrs. exploratory (EXT) pool Lackawanna field	1180 Mcf AF 1400 psi/48 hrs. exploratory (EXT) pool Lackawanna field	2000 Mcf AF 1480 psi/72 hrs. exploratory (EXT) Ligo volant field	1080 Mcf AF 1440 psi/48 hrs. development pool Lackawanna field	1374 Mcf AF 2396 psi/24 hrs. miscellaneous Greenlick Storage pool Leidy field	4760 Mcf AF 2431 psi/24 hrs. miscellaneous Greenlick Storage pool Leidy field	12799 Mcf AF 2419 psi/24 hrs. miscellaneous Greenlick Storage pool Leidy field	37886 Mcf AF 2422 psi/24 hrs. miscellaneous Greenlick Storage pool Leidy field	4016 Mcf AF 2444 psi/24 hrs. miscellaneous Greenlick Storage pool Leidy field

Figure 47. (Continued).

COUNTY PERMIT NUMBER	Potter 105-21042	Potter 105-21043	Somerset 111-20132	Somerset 111-20179	Somerset 111-20190	Somerset 111-20191	Somerset 111-20193	Somerset 111-20194	Tioga 117-20003	Venango 121-42631
NAME OF WELL	Tract 45 #RW-503	Tract 45 #RW-69	Ludy, Noah #1	Lape, Lester #1	McVicker #1-4143	Common PA TR 661 #2	Charlton #1-4152	Skeria, V. #1-4155	CNG Trans. #N-518S	Cubbon Lumber #9CI-1
OPERATOR	CNG Transmission Corp.	CNG Transmission Corp.	Atlantic Richfield Company	CNG Producing Company	CNG Producing Company	CNG Producing Company	CNG Producing Company	CNG Producing Company	CNG Transmission Corp.	Douglas Oil & Gas, Inc.
TOWNSHIP	Stewardson	Stewardson	Northampton	Jenner	Quemahoning	Middlecreek	Quemahoning	Somerset	Clymer	Cherrytree
QUADRANGLE	Young Womens Creek	Oleona	Fairhope	Somerset	Somerset	Kingwood	Somerset	Stoystown	Sabinsville	Titusville South
LATITUDE	1,150 ft. S 4,103'00"	13,950 ft. S 4,103'30"	1,000 ft. S 3,905'30"	1,325 ft. S 4,000'30"	7,350 ft. S 4,007'30"	2,525 ft. S 4,000'00"	250 ft. S 4,005'00"	4,000 ft. S 4,002'30"	320 ft. S 4,105'30"	10,000 ft. S 4,105'00"
LONGITUDE	1,200 ft. W 7,704'2'30"	8,125 ft. W 7,704'0'00"	10,800 ft. W 7,804'7'30"	10,275 ft. W 7,902'3'30"	4,650 ft. W 7,900'0'00"	7,650 ft. W 7,901'7'30"	1,230 ft. W 7,900'1'00"	10,700 ft. W 7,895'7'30"	6,450 ft. W 7,703'0'00"	9,000 ft. W 7,902'3'30"
DATE COMPLETED	9-17-89	9-24-89	4-25-84	8-19-89	8-29-89	1-19-90	2-19-90	1-21-90	6-13-90	9-1-89
ELEVATION	1828 GR	1751 GR	2083 GR	2143 GR	2025 GR	2636 GR	1995 GR	2187 GR	1647 GR	1570 GR
LOGS RECEIVED AND LOGGED INTERVALS	CNL/COL: 0-6739 CBL/VOL: 0-6713 OLL: 1234-6756 PCL: 6576-6594	CNL/CNL: 0-6606 DLL/GR: 1058-6623 CBL/VOL: 0-6540 PCL: 6476-6480		CNL/CNL: 0-9000	OLL: 1636-9083	COL/GR: 0-8498	CNL/LOT: 0-9104	CNL/LOT: 0-9285	CBL/VOL: 0-4453 PCL: 4343-4356	COL/CNL: 3885-5828
TULLY LIMESTONE	5710-	5586-	3250-	7752-	7924-	7492-	7826-	7950-	3551-	3902-
ONONDAGA LIMESTONE	6550-	6449-	3990-	8596- 8615-	8788- 8810-	8181- 8200-	8750- 8770-	8936- 8959-	4326-	4160-
ORISKANY SANDSTONE	6575-	6476-	4206-	8727-	8916-	8340-	8871-	9054-	4341-	4284-
RIDGELEY SANDSTONE	6618-	6516-	4506-	8790-	8962-	8373-	8894-	9084-	4365-	4310-
SILURIAN-DEVONIAN CARBONATES			4923-							4412- 5163-
SALINA GROUP LOCKPORT DOLOMITE										5436- 5506-
ROCHESTER SHALE IRONDEQUOIT DOLOMITE										5569- 5702- 5737-
GRIMSBY FORMATION CAROT HEAD SHALE WHIRLPOOL SANDSTONE										5745-
QUEENSTON FORMATION										
PRODUCING FORMATION	Ridgeley	Ridgeley					Ridgeley	Ridgeley	Ridgeley	Medina
DEEPEST PRODUCING DEPTH							8947	9162		5670
TOTAL DEPTH	6800	6640	8049	9015	9104	8530	9130	9314	4515	5860
DEEPEST FORMATION REACHED	Helderberg	Helderberg	Juniata	Helderberg	Helderberg	Helderberg	Helderberg	Helderberg	Helderberg	Queenston
RESULTS	5497 Mcf AF 2426 psi/24 hrs. miscellaneous Greenlick Storage pool Leidy field	69 Mcf AF 2291 psi/24 hrs. miscellaneous Greenlick Storage pool Leidy field	0ry and abandoned exploratory (NFW) Unnamed field	111 Mcf AF exploratory (NPW) Boswell field	Plugged and abandoned exploratory (EXT) Gideon Texas School field	Plugged and abandoned exploratory (NPW) Blue Hole field	2900 Mcf AF 3880 psi/312 hrs. exploratory (EXT) Gideon Texas School field	5000 Mcf AF 3525 psi/288 hrs. exploratory (NPW) Wells Creek pool Shanksville field	1007 Mcf AF 1345 psi/23 hrs. miscellaneous Sabinsville Storage field	1000 Mcf AF 1465 psi/72 hrs. development Tecca pool Hamilton Corners field

SUMMARIZED RECORDS OF DEEP WELLS

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COUNTY PERMIT NUMBER	Venango 121-42657	Venango 121-42658	Venango 121-42698	Venango 121-42702	Venango 121-42719	Venango 121-42723	Venango 121-42724	Venango 121-42728	Venango 121-42735	Venango 121-42746
NAME OF WELL	Cubbon Lumber #3CT1	Cubbon Lumber #3CT2	Fox-Ward Unit #2	Dallas #1	Shaffer, G. #1	Cunningham #2	CP Unit #19-1	Fennell #1	NFG #10	Hovis, T. #1
OPERATOR	Douglas Oil & Gas, Inc.	Douglas Oil & Gas, Inc.	Mark Resources Corp.	Mark Resources Corp.	Mark Resources Corp.	Quaker State Corporation	Mark Resources Corp.	Mark Resources Corp.	Cabot Oil & Gas Corp.	Cabot Oil & Gas Corp.
TOWNSHIP	Cherrytree	Cherrytree	Oakland	Cherrytree	Cherrytree	Cherrytree	Corplanter	Oakland	Oil Creek	Oakland
QUADRANGLE	Titusville South	Titusville South	Dempseytown	Titusville South	Titusville South	Titusville South	Titusville South	Dempseytown	Pleasantville	Franklin
LATITUDE	12,200 ft. S 4,1935.00"	13,650 ft. S 4,1935.00"	7,900 ft. S 4,1947.30"	6,710 ft. S 4,1935.00"	5,300 ft. S 4,1935.00"	350 ft. S 4,1932.30"	12,180 ft. S 4,1932.30"	9,100 ft. S 4,1932.30"	2,020 ft. S 4,1937.30"	470 ft. S 4,1930.00"
LONGITUDE	8,500 ft. W 7994.230"	9,150 ft. W 7994.230"	6,100 ft. W 7994.730"	6,890 ft. W 7994.000"	680 ft. W 7994.230"	4,240 ft. W 7994.230"	8,380 ft. W 7994.000"	2,250 ft. W 7994.730"	3,200 ft. W 7993.230"	3,800 ft. W 7994.730"
DATE COMPLETED	9-8-89	2-28-90	10-28-89	10-23-89	10-12-89	11-10-90	11-21-89	11-2-89	11-21-89	2-27-90
ELEVATION	1475 GR	1480 GR	1418 GR	1563 GR	1578 GR	1420 GR	1355 GR	1542 GR	1535 GR	1498 GR
LOGS RECEIVED AND LOGGED INTERVALS	COL/CNL: 3799-5784	COL/OLL: 892-5810 PCL: 5783-5809	GR/CBL: 4600-5640	GR/CBL: 4500-5874	GR/CBL: 4100-5789		GR/CBL: 4200-5841	GR/CBL: 4400-5861		
TULLY LIMESTONE	3843-	3844-	3736-	3948-		3811-	3884-	3904-	3931-	3912-
ONONDAGA LIMESTONE HUNTERSVILLE CHERT	4102-	4100-	3979-	4204-	4172-	4073-	4151-	4151-	4208-	4158-
ORISKANY SANDSTONE RIDGELY SANDSTONE	4222-	4220-	4100-	4314-	4297-	4194-	4251-	4275-	4322-	4280-
SILURIAN-DEVONIAN CARBONATES	4252-	4250-	4130-	4346-	4312-	4220-	4268-	4304-	4348-	4318-
SALINA GROUP LOCKPORT DOLOMITE	4350- 5088-	4346- 5094-	4288- 4968-	4498- 5156-		4377- 5056-	4307- 5137-	4468- 5138-	4648- 5070-	4646- 5112-
ROCHESTER SHALE IPONDEQUOIT DOLOMITE	5388- 5458-	5392- 5464-	5298- 5360-	5479- 5546-	5426- 5498-	5332- 5440-	5458- 5532-	5459- 5527-	5444- 5517-	5474- 5542-
GRIMSBY FORMATION CARBONIFEROUS SHALE WHIRLPOOL SANDSTONE	5530- 5650- 5696-	5526- 5650- 5694-	5428- 5546- 5600-	5744- 5778-	5560- 5688- 5724-	5505- 5631- 5671-	5587- 5720- 5770-	5600- 5727- 5762-	5572- 5723- 5744-	5608- 5745- 5778-
QUEENSTON FORMATION	5700-	5702-	5612-	5790-	5736-	5682-	5782-	5772-	5754-	5789-
PRODUCING FORMATION	Medina	Medina	Medina	Medina	Medina	Medina	Medina	Medina	Medina	Medina
DEEPEST PRODUCING DEPTH	5611	5625	5543	5742	5732	5679	5777	5712	5751	5694
TOTAL DEPTH	5822	5827	5681	5895	5833	5838	5882	5880	5858	5848
DEEPEST FORMATION REACHED	Queenston	Queenston	Queenston	Queenston	Queenston	Queenston	Queenston	Queenston	Queenston	Queenston
RESULTS	1200 Mcf AF 1450 psi/72 hrs. development pool Hamilton Corners field	1000 Mcf AF 1350 psi/48 hrs. development pool Hamilton Corners field	400 Mcf AF 1175 psi/432 hrs. development pool Beatty Run Cooperstown field	265 Mcf AF 1470 psi/72 hrs. development pool Cherrytree Run Toonerville field	250 Mcf AF 1375 psi/96 hrs. development pool Gresham Breedtown field	1700 Mcf AF 1380 psi/48 hrs. development pool Tecca Hamilton Corners field	115 Mcf AF 1375 psi/96 hrs. development pool Kancville Petrolium Center- Pioneer field	235 Mcf AF 1350 psi/792 hrs. development pool Beatty Run Cooperstown field	IP not reported 1500 psi/48 hrs. development pool Neiltown Pleasantville field	243 Mcf AF 1100 psi/48 hrs. development pool Beatty Run Cooperstown field

Figure 47. (Continued).

COUNTY PERMIT NUMBER	Venango 121-42763	Venango 121-42769	Venango 121-42773	Venango 121-42782	Venango 121-42790	Venango 121-42791	Venango 121-42795	Venango 121-42796	Venango 121-42797	Venango 121-42798
NAME OF WELL	Cornell #1	Goodlett, Rensma #1	Speer, O. #1	Cubbon Lumber #1	Capristo Unit #1	Hlopick, E. #1	Jones-Spangler #2	Cook, Hazel #1	Warner, James #1	Rhoades, Boyd #1-A
OPERATOR	Quaker State Corporation	Quaker State Corporation	Mark Resources Corp.	Mark Resources Corp.	Mark Resources Corp.	Cabot Oil & Gas Corp.	Mark Resources Corp.	Cabot Oil & Gas Corp.	Cabot Oil & Gas Corp.	Cabot Oil & Gas Corp.
TOWNSHIP	Cherrytree	Complanter	Oakland	Sugar Creek	Plum	Plum	Plum	Plum	Cherrytree	Oakland
QUADRANGLE	Titusville South	Titusville South	Franklin	Utica	Oempseytown	Oempseytown	Oempseytown	Oempseytown	Titusville South	Franklin
LATITUDE	3,050 ft. S 41°32'30"	2,300 ft. S 41°32'30"	800 ft. S 41°30'00"	13,260 ft. S 41°30'00"	5,850 ft. S 41°37'30"	6,190 ft. S 41°35'00"	9,250 ft. S 41°35'00"	3,570 ft. S 41°35'00"	4,930 ft. S 41°35'00"	6,570 ft. S 41°30'00"
LONGITUDE	5,400 ft. W 79°42'30"	4,410 ft. W 79°37'30"	8,100 ft. W 79°45'00"	2,020 ft. W 79°52'30"	2,340 ft. W 79°47'30"	6,000 ft. W 79°45'00"	150 ft. W 79°50'00"	8,250 ft. W 79°45'00"	1,900 ft. W 79°40'00"	5,980 ft. W 79°47'30"
DATE COMPLETED	11-4-89	12-1-89	12-6-89	12-28-89	11-14-89	11-17-89	11-21-89	1-4-90	12-16-89	10-25-89
ELEVATION	1450 GR	1445 GR	1532 GR	1278 GR	1426 GR	1326 GR	1441 GR	1390 GR	1632 GR	1521 GR
LOGS RECEIVED AND LOGGED INTERVALS			GR/CBL: 2500-5938	GR/CBL: 3750-5656	GR/CBL: 3900-5382	GR/COL: 803-5417 OIL: 0-5435	GR/CBL: 3800-5508	GR/COL: 760-5471	GR/PCL: 5545-5895	GR/PCL: 5580-5892
TULLY LIMESTONE	3847-	3966-	3985-	3712-	3558-	3608-	3677-	3660-	3193-	3978-
ONONDAGA LIMESTONE HUNTERSVILLE CHERT	4111-	4244-	4236-	3933-	3799-	3862-	3891-	3916-	4142-	4224-
ORISKANY SANDSTONE RIDGELEY SANDSTONE	4227-	4344-	4355-	4061-	3947-	3990-	4036-	4048-	4272-	4348-
SILURIAN-DEVONIAN CARBONATES	4248-	4359-	4380-	4090-	3970-	4010-	4065-	4069-	4387-	4374-
SALINA GROUP LOCKPORT DOLOMITE	4413- 5107-	4528- 5215-	4499- 5236-	4207- 4943-	4102- 4709-	4110- 4804-	4209- 4837-	4168- 4868-	4412- 4720-	4713- 5188-
ROCHESTER SHALE IRONDEQUOIT DOLOMITE	5370- 5481-	5539- 5615-	5558- 5630-	5262- 5337-	5029- 5094-	5102- 5170-	5158- 5224-	5150- 5212-	5180- 5346-	5550- 5620-
GRIMSBY FORMATION CABOT HEAD SHALE WHIRLPOOL SANDSTONE	5546- 5672- 5712-	5666- 5811- 5850-	5748- 5795- 5866-	5404- 5546- 5577-	5152- 5285- 5317-	5228- 5359- 5397-	5290- 5393- 5450-	5270- 5404- 5438-	5624- 5777- 5796-	5676- 5826- 5863-
QUEENSTON FORMATION	5723-	5864-	5886-	5587-	5327-	5406-	5460-	5448-	5820-	5876-
PRODUCING FORMATION	Medina	Medina	Medina	Medina	Medina	Medina	Medina	Medina	Medina	Medina
DEEPEST PRODUCING DEPTH	5716	5862	5804	5519	5246	5310	5391	5347	5755	5759
TOTAL DEPTH	5863	6015	5988	5695	5444	5478	5561	5516	5908	5939
DEEPEST FORMATION REACHED	Queenston	Queenston	Queenston	Queenston	Queenston	Queenston	Queenston	Queenston	Queenston	Queenston
RESULTS	1600 Mcf AF 1400 psi/48 hrs. development Tesza pool Hamilton Corners field	1600 Mcf AF 520 psi/48 hrs. exploratory (OPW) Oil Creek pool Petroleum Center- Pioneer field	105 Mcf AF 1435 psi/72 hrs. development Mt. Carmel pool Oempseytown field	95 Mcf AF 1410 psi/192 hrs. development Takitezy pool sugar Creek-Hilles field	265 Mcf AF 1455 psi/72 hrs. development diamond pool Troy field	379 Mcf AF 1150 psi/48 hrs. development Beatty Run pool Cooperstown field	100 Mcf AF 1420 psi/72 hrs. development Beatty Run pool Cooperstown field	IP not reported 1420 psi/48 hrs. development Beatty Run pool Cooperstown field	371 Mcf AF 1025 psi/48 hrs. development Orakett pool Octave field	203 Mcf AF 1370 psi/48 hrs. development Beatty Run pool Cooperstown field

SUMMARIZED RECORDS OF DEEP WELLS

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COUNTY PERMIT NUMBER	Venango 121-42799	Venango 121-42800	Venango 121-42804	Venango 121-42805	Venango 121-42808	Venango 121-42809	Venango 121-42812	Venango 121-42813	Venango 121-42814	Venango 121-42815
NAME OF WELL	Zdarko, Edward #2	Zdarko, Edward #2	Frederick, Don #3A	Ellen, Elizabeth #3	Spangler Unit #3A	Ellison, G. #1	Anderson Unit #1	Buxton, Kinley #2	Nichols-Sokol #1	Johnson, D. #1
OPERATOR	Cabot Oil & Gas Corp.	Quaker State Corporation	Cabot Oil & Gas Corp.	Cabot Oil & Gas Corp.	Mark Resources Corp.	Cabot Oil & Gas Corp.	Mark Resources Corp.	Quaker State Corporation	Mark Resources Corp.	Cabot Oil & Gas Corp.
TOWNSHIP	Cherrytree	Cherrytree	Cherrytree	Cherrytree	Oakland	Cherrytree	Cherrytree	Cherrytree	Cherrytree	Oakland
QUADRANGLE	Titusville South	Titusville South	Titusville South	Titusville South	Dempseytown	Titusville South	Titusville South	Titusville South	Titusville South	Franklin
LATITUDE	6,000 ft. S 41°35'00"	8,420 ft. S 41°35'00"	12,710 ft. S 41°35'00"	9,400 ft. S 41°35'00"	3,300 ft. S 41°32'30"	12,150 ft. S 41°35'00"	6,070 ft. S 41°35'00"	3,770 ft. S 41°35'00"	13,900 ft. S 41°37'30"	4,900 ft. S 41°30'00"
LONGITUDE	360 ft. W 79°40'00"	2,420 ft. W 79°40'00"	7,400 ft. W 79°42'30"	1,230 ft. W 79°42'30"	10,590 ft. W 79°45'00"	7,190 ft. W 79°42'30"	4,320 ft. W 79°40'00"	4,010 ft. W 79°42'30"	3,860 ft. W 79°42'30"	5,000 ft. W 79°47'30"
DATE COMPLETED	10-2-90	3-3-90	1-16-90	12-6-89	12-20-89	12-5-89	12-30-89	3-4-90	3-27-90	12-8-89
ELEVATION	1545 GR	1600 GR	1414 GR	1460 GR	1333 GR	1531 GR	1592 GR	1555 GR	1389 GR	1505 GR
LOGS RECEIVED AND LOGGED INTERVALS			GR/DLL: 760-5501	GR/PCL: 5380-5699	GR/CBL: 4500-5588	GR/PCL: 5450-5761	GR/CBL: 4200-5864		GR/CBL: 3600-5587	GR/CBL: 4227-5855
TULLY LIMESTONE	3936-		3674-	3820-	3668-	3883-	3977-	3875-	3679-	3954-
QUONDAGA LIMESTONE HUNTERSVILLE CHERT	4208-	4260-	3930-	4085-	3916-	4140-	4248-	4138-	3939-	4202-
ORISKANY SANDSTONE RIDGELEY SANDSTONE	4320-		4058-	4202-	4040-	4264-	4362-		4066-	4322-
SILURIAN-DEVONIAN CARBONATES	4366-	4379-	4075-	4230-	4068-	4291-	4385-	4280-	4086-	4350-
SALINA GROUP LOCKPORT DOLOMITE	4668- 5127-	4510- 4565-	4170- 4870-	4543- 5010-	4226- 4894-	4617- 5064-	4538- 5201-	4431- 5091-	4228- 4861-	4690- 5214-
ROCHESTER SHALE IRONDEQUOIT DOLOMITE	5505- 5562-	5253- 5539-	5154- 5224-	5389- 5440-	5214- 5282-	5424- 5466-	5506- 5591-	5334- 5461-	5176- 5305-	5522- 5587-
GRIMSBY FORMATION CABOT HEAD SHALE WHIRLPOOL SANDSTONE	5621- 5767- 5795-	5664- 5787- 5825-	5284- 5518- 5450-	5504- 5642- 5674-	5348- 5472- 5515-	5560- 5695- 5726-	5696- 5798- 5824-	5525- 5644- 5689-	5313- 5439- 5476-	5652- 5790- 5824-
QUEENSTON FORMATION	5805-	5860-	5458-	5684-	5525-	5738-	5835-	5701-	5488-	5838-
PRODUCING FORMATION	Medina	Medina	Medina	Medina	Medina	Medina	Medina	Medina	Medina	Medina
DEEPEST PRODUCING DEPTH	5730	5811	5358	5596	5470	5625	5766	5697	5417	5740
TOTAL DEPTH	5875	6000	5530	5768	5637	5808	5931	5825	5587	5916
DEEPEST FORMATION REACHED	Queenston	Queenston	Queenston	Queenston	Queenston	Queenston	Queenston	Queenston	Queenston	Queenston
RESULTS	468 Mcf AF 1410 psi/48 hrs. development Drake Well pool Octave field	1200 Mcf AF 1290 psi/48 hrs. development Cherrytree Run pool Toonerville field	323 Mcf AF 1200 psi/48 hrs. development Gresham pool Breedtown field	284 Mcf AF 1290 psi/48 hrs. development Tecza pool Hamilton Corners field	240 Mcf AF 1150 psi/432 hrs. development Beatty Run pool Coopers town field	206 Mcf AF 1130 psi/72 hrs. development Tecza pool Hamilton Corners field	130 Mcf AF 1480 psi/72 hrs. development Cherrytree pool Toonerville field	1600 Mcf AF 1165 psi/48 hrs. development Tecza pool Hamilton Corners field	240 Mcf AF 1425 psi/456 hrs. development pool Hamilton Corners field	373 Mcf AF 1530 psi/120 hrs. development Beatty Run pool Coopers town field

Figure 47. (Continued).

COUNTY PERMIT NUMBER	Venango 121-42827	Venango 121-42836	Venango 121-42838	Venango 121-42841	Venango 121-42842	Venango 121-42843	Venango 121-42844	Venango 121-42845	Venango 121-42848	Venango 121-42850
NAME OF WELL	C.P. Unit #6-1	Olson Unit #1	Grela, Helen #1	Johnson, Henry #1	Fox-Ward Unit #4	Fox-Ward Unit #5	CP Unit #9-1	Smith/Lytton #1	Roskov #1	CP Unit #11-1
OPERATOR	Mark Resources Corp.	Mark Resources Corp.	Cabot Oil & Gas Corp.	Cabot Oil & Gas Corp.	Mark Resources Corp.	Mark Resources Corp.	Mark Resources Corp.	Mark Resources Corp.	Mark Resources Corp.	Mark Resources Corp.
TOWNSHIP	Complanter	Oakland	Sugar Creek	Sugar Creek	Oakland	Oakland	Complanter	Oakland	Plum	Complanter
QUADRANGLE	Titusville South	Titusville South	Franklin	Franklin	Oempseytown	Oempseytown	Pleasantville	Oempseytown	Oempseytown	Pleasantville
LATITUDE	2,500 ft. S 4,1032'30"	3,400 ft. S 4,1032'30"	14,660 ft. S 4,1030'00"	950 ft. S 4,1027'30"	6,900 ft. S 4,1032'30"	5,190 ft. S 4,1032'30"	4,300 ft. S 4,1032'30"	5,400 ft. S 4,1032'30"	4,800 ft. S 4,1035'00"	6,090 ft. S 4,1032'30"
LONGITUDE	2,600 ft. W 7,9037'30"	10,950 ft. W 7,9042'30"	4,400 ft. W 7,9050'00"	10,100 ft. W 7,9030'00"	4,710 ft. W 7,9047'30"	4,980 ft. W 7,9047'30"	10,430 ft. W 7,9035'00"	1,600 ft. W 7,9047'30"	3,500 ft. W 7,9050'00"	9,990 ft. W 7,9035'00"
DATE COMPLETED	1-18-90	3-1-90	7-17-90	6-28-90	9-11-90	10-3-90	7-24-90	7-24-90	9-5-90	9-17-90
ELEVATION	1575 GR	1545 GR	1460 GR	1465 GR	1350 GR	1369 GR	1400 GR	1380 GR	1460 GR	1639 GR
LOGS RECEIVED AND LOGGED INTERVALS	GR/CBL: 4350-6019							GR/CBL: 3900-5648		
TULLY LIMESTONE		3920-	3930-	3903-	3676-	3665-	3966-		3651-	4224-
ONONDAGA LIMESTONE HUNTERSVILLE CHERT		4178-	4164-	4133-	3922-	3914-	4240-	3974-	3884-	4494-
ORISKANY SANDSTONE RIDGELEY SANDSTONE		4300-	4285-	4252-	4046-	4041-	4340-		4018-	4592-
SILURIAN-DEVONIAN CARBONATES		4322-	4309-	4278-	4062-	4072-	4364-	4096-	4050-	4600-
SALINA GROUP LOCKPORT DOLOMITE		4486-	4612- 5208-	4577- 5184-	4234- 4940-	4230- 4942-	4530- 5254-	4230- 4950-	4190- 4850-	4784- 5508-
ROCHESTER SHALE IRONDEQUOIT DOLOMITE		5465- 5549-	5505- 5578-	5454- 5544-	5234-	5224- 5296-	5544- 5614-	5276- 5350-	5142- 5202-	5800- 5870-
GRIMSBY FORMATION CABOT HEAD SHALE WHIRLPOOL SANDSTONE		5807- 5959- 5985-	5646- 5780- 5813-	5612- 5749- 5784-	5418- 5502- 5532-	5418- 5493- 5528-	5722- 5816- 5848-	5414- 5547- 5583-	5326- 5384- 5430-	6000- 6082- 6106-
QUEENSTON FORMATION		5791-	5828-	5798-	5543-	5544-	5864-	5596-	5440-	6126-
PRODUCING FORMATION	Medina	Medina	Medina	Medina	Medina	Medina	Medina	Medina	Medina	Medina
DEEPEST PRODUCING DEPTH	5916	5735	5746	5698	5478	5468	5799	5498	5358	6053
TOTAL DEPTH	6104	5890	5892	5870	5654	5636	5958	5665	5499	6226
DEEPEST FORMATION REACHED	Queenston	Queenston	Queenston	Queenston	Queenston	Queenston	Queenston	Queenston	Queenston	Queenston
RESULTS	225 Mcf AF 1200 psi/120 hrs. development Oil Creek pool Pioneer field	125 Mcf AF 1310 psi/512 hrs. development Ht. Creek pool Oempseytown field	IP not reported 1340 psi/48 hrs. development Gardway pool Franklin-Oak Forest field	256 Mcf AF 940 psi/48 hrs. development Gardway pool Franklin-Oak Forest field	100 Mcf AF 1150 psi/192 hrs. development Beatty Run pool Cooperstown field	330 Mcf AF 1275 psi/196 hrs. development Beatty Run pool Cooperstown field	60 Mcf AF 1460 psi/20 hrs. exploratory (OPW) Cooperstown pool Rattlesnake field	390 Mcf AF 1485 psi/144 hrs. development Beatty Run pool Cooperstown field	130 Mcf AF 1000 psi/96 hrs. development Beatty Run pool Cooperstown field	280 Mcf AF 1480 psi/216 hrs. development Cooperstown pool Rattlesnake field

COUNTY PERMIT NUMBER	Venango 121-42851	Venango 121-42853	Venango 121-42854	Venango 121-42856	Venango 121-42857	Venango 121-42858	Venango 121-42865	Venango 121-42869	Venango 121-42870	Venango 121-42872
NAME OF WELL	McCarthy, J. #1A	Rice, Francis #1	Kohl, D. #11	Mast #1	Lange, John #1	Allender, V. #2	Feevey, T. #1	Patterson #1	C.P. Unit #8-1	Patterson Unit #2
OPERATOR	Cabot Oil & Gas Corp.	Cabot Oil & Gas Corp.	Mark Resources Corp.	Mark Resources Corp.	Cabot Oil & Gas Corp.	Cabot Oil & Gas Corp.	Mark Resources Corp.	Mark Resources Corp.	Mark Resources Corp.	Mark Resources Corp.
TOWNSHIP	Jackson	Sugar Creek	Plum	Plum	Canal	Cherrytree	Plum	Plum	Complanter	Plum
QUADRANGLE	Franklin	Franklin	Dempseytown	Dempseytown	Utica	Titusville South	Dempseytown	Dempseytown	Titusville South	Dempseytown
LATITUDE	7 300 ft. S 41°30'00"	2 600 ft. S 41°27'30"	13 960 ft. S 41°35'00"	7 880 ft. S 41°37'30"	3 870 ft. S 41°30'00"	14 350 ft. S 41°37'30"	8 900 ft. S 41°37'30"	12 120 ft. S 41°37'30"	4 240 ft. S 41°32'30"	11 050 ft. S 41°37'30"
LONGITUDE	2 100 ft. W 79°50'00"	6 250 ft. W 79°50'00"	10 620 ft. W 79°47'30"	2 700 ft. W 79°47'30"	7 180 ft. W 79°55'00"	370 ft. W 79°42'30"	4 650 ft. W 79°47'30"	5 100 ft. W 79°47'30"	2 960 ft. W 79°37'30"	3 540 ft. W 79°47'30"
DATE COMPLETED	7-12-90	7-10-90	8-13-90	8-13-90	7-19-90	8-10-90	8-28-90	9-4-90	7-10-90	8-20-90
ELEVATION	1460 GR	1435 GR	1476 GR	1449 GR	1500 GR	1510 GR	1489 GR	1438 GR	1465 GR	1511 GR
LOGS RECEIVED AND LOGGED INTERVALS										
TULLY LIMESTONE	3840-	3926-	3728-	3616-	3751-	3810-	3657-	3624-	3992-	3694-
ONONDAGA LIMESTONE HUNTERSVILLE CHERT	4077-	4160-	3966-	3856-	3980-	4066-	3898-	3864-	4264-	3936-
ORISKANY SANDSTONE RIDGELEY SANDSTONE	4202-	4284-	4098-	4000-	4114-	4194-	4042-	4006-	4364-	4080-
SILURIAN-DEVONIAN CARBONATES	4231-	4306-	4130-	4018-	4141-	4220-	4067-	4025-	4380-	4106-
SALINA GROUP LOCKPORT DOLOMITE	4572- 5122-	4606- 5222-	4274- 4984-	4160- 4802-	4472- 5013-	4544- 5038-	4201- 4840-	4170- 4794-	4556- 5292-	4237- 4892-
ROCHESTER SHALE IPONDEQUOIT DOLOMITE	5409- 5480-	5493- 5572-	5248- 5314-	5057- 5152-	5295- 5368-	5326- 5395-	5126- 5190-	5094- 5156-	5564- 5642-	5160- 5222-
GRIMSBY FORMATION CABOT HEAD SHALE WHIRLPOOL SANDSTONE	5548- 5680- 5715-	5642- 5785- 5814-	5426- 5454- 5538-	5264- 5328- 5366-	5428- 5364- 5602-	5458- 5592- 5620-	5298- 5384- 5414-	5278- 5351- 5384-	5752- 5843- 5876-	5340- 5416- 5446-
QUEENSTON FORMATION	5728-	5829-	5552-	5386-	5614-	5736-	5425-	5394-	5896-	5458-
PRODUCING FORMATION	Medina	Medina	Medina	Medina	Medina	Medina	Medina	Medina	Medina	Medina
DEEPEST PRODUCING DEPTH	5613	5718	5489	5322	5516	5527	5346	5332	5890	5387
TOTAL DEPTH	5790	5888	5632	5468	5705	5736	5479	5480	5953	5545
DEEPEST FORMATION REACHED	Queenston	Queenston	Queenston	Queenston	Queenston	Queenston	Queenston	Queenston	Queenston	Queenston
RESULTS	482 Mcf AF 1450 psi/48 hrs. development Beatty Run Coopers town field	IP not reported 1540 psi/48 hrs. development Galloway Franklin Oak Forest field	325 Mcf AF 1485 psi/72 hrs. development Beatty Run Coopers town field	135 Mcf AF 1200 psi/144 hrs. development Beatty Run Coopers town field	281 Mcf AF 1240 psi/48 hrs. development Canal McClure Run field	235 Mcf AF 1320 psi/48 hrs. development Gresham pool Bracefield field	98 Mcf AF 1350 psi/168 hrs. development Beatty Run pool Coopers town field	250 Mcf AF 1300 psi/120 hrs. development Beatty Run pool Coopers town field	175 Mcf AF 1450 psi/168 hrs. development Petroleum Center- pool Pioneer field	300 Mcf AF 1400 psi/144 hrs. development Beatty Run pool Coopers town field

Figure 47. (Continued).

COUNTY PERMIT NUMBER	Venango 121-42880	Venango 121-42886	Venango 121-42887	Venango 121-42891	Venango 121-42892	Venango 121-42897	Venango 121-42899	Venango 121-42900	Venango 121-42902	Venango 121-42904
NAME OF WELL	Sauerland, Sagan #2	Kightlinger, E. #2	Beightol, R. #1	Mong, Merle #1	Stolenburg, L. #1	Fisher, Gerald #4	Plyler Unit #2	Turner, Harold #1	Carlil, K. #1-A	Brenner, J. #1
OPERATOR	Cabot Oil & Gas Corp.	Cabot Oil & Gas Corp.	Cabot Oil & Gas Corp.	Cabot Oil & Gas Corp.	Cabot Oil & Gas Corp.	Cabot Oil & Gas Corp.	Mark Resources Corp.	Cabot Oil & Gas Corp.	Cabot Oil & Gas Corp.	Cabot Oil & Gas Corp.
TOWNSHIP	Plum	Plum	Canal	Oakland	Canal	Jackson	Oakland	Oakland	Oakland	Plum
QUADRANGLE	Oempseytown	Oempseytown	Utica	Franklin	Sugar Lake	Franklin	Oempseytown	Franklin	Franklin	Oempseytown
LATITUDE	6,100 ft. S 4,103'7"30"	1,980 ft. S 4,103'7"30"	3,800 ft. S 4,102'7"30"	10,160 ft. S 4,103'0"00"	12,520 ft. S 4,103'2"30"	9,050 ft. S 4,103'0"00"	550 ft. S 4,103'2"30"	8,100 ft. S 4,103'0"00"	1,000 ft. S 4,103'0"00"	12,370 ft. S 4,103'7"30"
LONGITUDE	5,210 ft. W 7904'7"30"	5,420 ft. W 7904'7"30"	10,840 ft. W 7905'5"00"	7,420 ft. W 7904'7"30"	5,520 ft. W 7905'5"00"	1,450 ft. W 7905'0"00"	3,980 ft. W 7905'0"00"	2,520 ft. W 7904'7"30"	5,730 ft. W 7904'7"30"	8,200 ft. W 7904'7"30"
DATE COMPLETED	7-31-90	8-28-90	8-22-90	9-5-90	9-5-90	9-15-90	9-19-90	9-25-90	10-4-90	10-6-90
ELEVATION	1531 GR	1555 GR	1192 GR	1523 GR	1612 GR	1322 GR	1492 GR	1525 GR	1358 GR	1568 GR
LOGS RECEIVED AND LOGGED INTERVALS										
TULLY LIMESTONE	3652-	3626-	3541-	4009-	3834-	3794-	3848-	4020-	3756-	3738-
ONONDAGA LIMESTONE HUNTERSVILLE CHERT	3890-	3862-	3760-	4254-	4052-	4033-	4100-	4266-	4001-	3974-
ORISKANY SANDSTONE RIDGELEY SANDSTONE	4038-	4018-	3892-	4375-	4194-	4156-	4223-	4384-	4121-	4115-
SILURIAN-DEVONIAN CARBONATES	4064-	4043-	3920-	4400-	4217-	4184-	4252-	4408-	4150-	4144-
SALINA GROUP LOCKPORT DOLOMITE	4360- 4841-	4332- 4820-	4254- 4810-	4742- 5294-	4544- 5079-	4526- 5070-	4410- 5102-	4757- 5302-	4485- 5031-	4441- 4858-
ROCHESTER SHALE IRONDEQUOIT DOLOMITE	5131- 5191-	5100- 5169-	5082- 5168-	5581- 5653-	5370- 5433-	5360- 5428-	5398- 5469-	5592- 5666-	5317- 5391-	5207- 5276-
GRIMSBY FORMATION CABOT HEAD SHALE WHIRLPOOL SANDSTONE	5248- 5370- 5410-	5226- 5354- 5390-	5234- 5386- 5412-	5723- 5847- 5891-	5491- 5630- 5667-	5498- 5629- 5663-	5592- 5648- 5698-	5736- 5871- 5905-	5458- 5596- 5626-	5336- 5468- 5502-
QUEENSTON FORMATION	5420-	5400-	5424-	5902-	5678-	5678-	5710-	5918-	5637-	5512-
PRODUCING FORMATION	Medina	Medina	Medina	Medina	Medina	Medina	Medina	Medina	Medina	Medina
DEEPEST PRODUCING DEPTH	5322	5340	5345	5790	5590	5592	5622	5865	5537	5423
TOTAL DEPTH	5485	5536	5533	5996	5749	5745	5803	5993	5759	5585
DEEPEST FORMATION REACHED	Queenston	Queenston	Queenston	Queenston	Queenston	Queenston	Queenston	Queenston	Queenston	Queenston
RESULTS	429 Mcf AF 1320 psi/48 hrs. development Diamond pool roy field	286 Mcf AF 1390 psi/0 hrs. development Diamond pool roy field	253 Mcf AF 1160 psi/48 hrs. development Canal McCune Run field	213 Mcf AF 1260 psi/0 hrs. development Galloway pool Franklin-Dak Forest field	279 Mcf AF 1060 psi/48 hrs. development Beatty Run pool Coopers town field	278 Mcf AF 1320 psi/48 hrs. development Beatty Run pool Coopers town field	175 Mcf AF 1440 psi/72 hrs. development Tezca pool Hamilton Corners field	293 Mcf AF 1350 psi/48 hrs. development Beatty Run pool Coopers town field	259 Mcf AF 1050 psi/48 hrs. development Beatty Run pool Coopers town field	301 Mcf AF 1140 psi/48 hrs. development Beatty Run pool Coopers town field

SUMMARIZED RECORDS OF DEEP WELLS

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COUNTY PERMIT NUMBER	Venango 121-42905	Venango 121-42907	Venango 121-42908	Venango 121-42909	Venango 121-42913	Venango 121-42917	Venango 121-42921	Venango 121-42924	Venango 121-42926	Warren 123-59227
NAME OF WELL	Sokol, Thomas #1-A	Dunkley, L. #1	Shrock #1	Grundman, K. #2-A	Tarr, Merwin #1	Snyder, Evelyn #2	Beals, Norman #1	Dewey, Ronald #1	Wright, Lester #2	Cubbon Lumber #3
OPERATOR	Cabot Oil & Gas Corp.	Cabot Oil & Gas Corp.	Mark Resources Corp.	Cabot Oil & Gas Corp.	Cabot Oil & Gas Corp.	Cabot Oil & Gas Corp.	Cabot Oil & Gas Corp.	Quaker State Corporation	Cabot Oil & Gas Corp.	Douglas Oil & Gas, Inc.
TOWNSHIP	Plum	Canal	Plum	Cherrytree	Oakland	Sugar Creek	Oakland	Cherrytree	Canal	Southwest
QUADRANGLE	Dempseytown	Utica	Dempseytown	Titusville South	Franklin	Franklin	Dempseytown	Titusville South	Utica	Grand Valley
LATITUDE	10,150 ft. S 41°37'30"	2,000 ft. S 41°02'30"	6,650 ft. S 41°37'30"	6,700 ft. S 41°05'00"	700 ft. S 41°30'00"	300 ft. S 41°27'30"	14,400 ft. S 41°32'30"	10,325 ft. S 41°35'00"	3,200 ft. S 41°30'00"	3,650 ft. S 41°40'00"
LONGITUDE	5,340 ft. W 79°57'30"	1,430 ft. W 79°57'30"	3,860 ft. W 79°57'30"	5,230 ft. W 79°52'30"	10,020 ft. W 79°54'00"	3,730 ft. W 79°57'30"	4,650 ft. W 79°57'30"	1,050 ft. W 79°40'00"	10,150 ft. W 79°57'30"	4,500 ft. W 79°32'30"
DATE COMPLETED	10-24-90	9-15-90	9-25-90	10-4-90	10-11-90	11-6-90	10-17-90	11-29-90	11-2-90	1-27-88
ELEVATION	1484 GR	1128 GR	1530 GR	1574 GR	1517 GR	1460 GR	1493 GR	1610 GR	1526 GR	1576 GR
LOGS RECEIVED AND LOGGED INTERVALS										CDL/CNL: 3850-5783 PCL: 5350-5721
TULLY LIMESTONE	3652-	3458-	3672-	3904-	3958-	4008-	3879-	4020-	3711-	3876-
ONONDAGA LIMESTONE HUNTERSVILLE CHERT	3890- 4032-	3681-	3914-	4160-	4207-	4258-	4122-	4291-	3930-	4160-
ORISKANY SANDSTONE RIDGLEY SANDSTONE	4058- 4348-	3818-	4060-	4284-	4324-	4376-	4243-	4402-	4075-	4271-
SILURIAN-DEVONIAN CARBONATES	4766-	3852-	4084-	4310-	4352-	4397-	4275-	4423-	4106-	4300-
SALINA GROUP LOCKPORT DOLOMITE	5128- 5193-	4185- 4732-	4218- 4864-	4628- 5067-	4700- 5159-	4746- 5226-	4610- 5080-	4583- 5274-	4430- 4884-	4380- 5066-
ROCHESTER SHALE IRONDEQUOIT DOLOMITE	5252- 5582-	5020- 5086-	5148- 5208-	5424- 5494-	5521- 5593-	5501- 5666-	5444- 5511-	5558- 5646-	5350- 5514-	5356- 5424-
GRIMSBY FORMATION CABOT HEAD SHALE WHIRLPOOL SANDSTONE	5416- 5426-	5150- 5302- 5329-	5314- 5395- 5429-	5556- 5689- 5724-	5660- 5795- 5828-	5736- 5868- 5907-	5577- 5707- 5744-	5701- 5846- 5879-	5368- 5518- 5555-	5474- 5608- 5654-
QUEENSTON FORMATION		5341-	5442-	5735-	5841-	5918-	5755-	5890-	5565-	5664-
PRODUCING FORMATION	Medina	Medina	Medina	Medina	Medina	Medina	Medina	Medina	Medina	Medina
DEEPEST PRODUCING DEPTH	5325	5294	5373	5666	5794	5827	5660	5886	5481	5660
TOTAL DEPTH	5491	5429	5524	5806	5944	6023	5840	6015	5630	5783
DEEPEST FORMATION REACHED	Queenston	Queenston	Queenston	Queenston	Queenston	Queenston	Queenston	Queenston	Queenston	Queenston
RESULTS	IP not reported 1275 psi/48 hrs. development Beatty Run pool Cooperstown field	253 Mcf AF 1360 psi/48 hrs. development Canal McCune Run field	135 Mcf AF 1300 psi/120 hrs. development Diamond pool Troy field	246 Mcf AF 1260 psi/48 hrs. development Tecca pool Hamilton Corners field	591 Mcf AF 1350 psi/48 hrs. development Mt. Carmel pool Dempseytown field	IP not reported 1400 psi/48 hrs. exploratory Galloway pool Franklin-Oak Forest field	IP not reported 1440 psi/0 hrs. development Cherrytree Run pool Tonerville field	252 Mcf AF 1300 psi/48 hrs. development Beatty Run pool Cooperstown field	365 Mcf AF 930 psi/48 hrs. development Cochran field	750 Mcf AF 1360 psi/72 hrs. development Campbell Creek pool Goodwill Hill- Grand Valley field

Figure 47. (Continued).

COUNTY PERMIT NUMBER	Warren 123-40018	Warren 123-40414	Warren 123-40440	Warren 123-40456	Warren 123-40457	Warren 123-40489	Warren 123-40554	Warren 123-40563	Warren 123-40574	Warren 123-40577
NAME OF WELL	Nichols #4	Brundage, Martin #2	Steffens #2	Rybacki-Stredman #1	Merry, Mildred #4	French #1	Reagle, Paul #1	Malek, Joseph #1	Rybacki Unit #1	Malek, J. #2
OPERATOR	Douglas Oil & Gas, Inc.	Douglas Oil & Gas, Inc.	Douglas Oil & Gas, Inc.	Douglas Oil & Gas, Inc.	Douglas Oil & Gas, Inc.	Douglas Oil & Gas, Inc.	Douglas Oil & Gas, Inc.	Douglas Oil & Gas, Inc.	Douglas Oil & Gas, Inc.	Douglas Oil & Gas, Inc.
TOWNSHIP	Spring Creek	Spring Creek	Spring Creek	Spring Creek	Spring Creek	Spring Creek	Freehold	Columbus	Spring Creek	Columbus
QUADRANGLE	Spring Creek	Spring Creek	Spring Creek	Spring Creek	Spring Creek	Spring Creek	Lottsville	Columbus	Spring Creek	Columbus
LATITUDE	10,750 ft. S 4,105'00"	2,800 ft. S 4,105'00"	6,300 ft. S 4,105'00"	3,975 ft. S 4,105'00"	15,100 ft. S 4,105'00"	2,400 ft. S 4,105'00"	3,550 ft. S 4,105'730"	3,450 ft. S 4,105'00"	5,525 ft. S 4,105'00"	3,550 ft. S 4,105'00"
LONGITUDE	4,950 ft. W 7,935'00"	10,400 ft. W 7,932'30"	11,400 ft. W 7,930'00"	5,700 ft. W 7,935'00"	7,700 ft. W 7,935'00"	6,265 ft. W 7,935'00"	8,700 ft. W 7,927'30"	5,450 ft. W 7,930'00"	5,550 ft. W 7,935'00"	7,000 ft. W 7,930'00"
DATE COMPLETED	11-2-88	10-25-88	1-17-89	10-28-88	10-22-88	11-22-88	3-9-89	8-7-89	2-6-89	8-19-89
ELEVATION	1648 GR	1650 GR	1595 GR	1560 GR	1585 GR	1545 GR	1660 GR	1765 GR	1540 GR	1730 GR
LOGS RECEIVED AND LOGGED INTERVALS	CDL/CNL: 3350-5193 PCL: 4800-5111	CDL/CNL: 3350-5129	CDL/CNL: 3350-5169 PCL: 4700-5122	CDL/CNL: 3250-5013	CDL/CNL: 3361-5168 DLL: 3361-5185 INT: 4900-5069 PCL: 3100-5131	CDL/CNL: 3238-5103		CDL/CNL: 3200-4943 GR/PCL: 4650-4958	CDL/CNL: 3100-4951 INT: 4750-4920	CDL/GR: 3155-4857 PCL: 3000-4834 DLL: 3510-4773
TULLY LIMESTONE	3397-	3382-	3382-	3254-	3392-	3330-	2968-	3242-	3254-	3200-
ONONDAGA LIMESTONE HUNTERSVILLE CHERT	3654-	3642-	3650-	3510-	3652-	3584-	3350-	3530-	3512-	3492-
ORISKANY SANDSTONE RIDGELEY SANDSTONE										
SILURIAN-DEVONIAN CARBONATES	3800-	3786-	3794-	3656-	3800-	3733-	3512-	3690-	3662-	3652-
SALINA GROUP LOCKPORT DOLOMITE	3870- 4508-	3848- 4458-	3862- 4482-	3722- 4351-	3864- 4510-	3800- 4434-	3573- 4158-	3762- 4346-	3728- 4364-	3718- 4316-
ROCHESTER SHALE IRONDEQUOIT DOLOMITE	4790- 4844-	4747- 4796-	4770- 4826-	4646- 4698-	4780- 4846-	4708- 4774-	4396- 4480-	4628- 4680-	4646- 4700-	4598- 4638-
GRIMSBY FORMATION CAROT HEAD SHALE WHIRLPOOL SANDSTONE	4804- 5024- 5053-	4837- 4978- 5006-	4872- 5004- 5046-	4760- 4883- 4906-	4897- 5024- 5057-	4824- 4948- 4982-	4514- 4662- 4688-	4718- 4844- 4892-	4746- 4879- 4908-	4672- 4825- 4861-
QUEENSTON FORMATION	5062-	5017-	5050-	4916-	5066-	4994-	4698-	4900-	4913-	4872-
PRODUCING FORMATION	Medina	Medina	Medina	Medina	Medina	Medina	Medina	Medina	Medina	Medina
DEEPEST PRODUCING DEPTH	5059	5102	4968	4911	5062	4985	4603	4894	4912	4764
TOTAL DEPTH	5193	5129	5180	5013	5209	5142	4800	5015	5000	4973
DEEPEST FORMATION REACHED	Queenston	Queenston	Queenston	Queenston	Queenston	Queenston	Queenston	Queenston	Queenston	Queenston
RESULTS	1400 Mcf AF 1280 psi/72 hrs. development County Line field	1200 Mcf AF 1280 psi/72 hrs. development County Line field	1800 Mcf AF 1300 psi/72 hrs. development Trim pool Sumner field	3000 Mcf AF 1335 psi/72 hrs. development West Spring Creek pool Spring Creek field	1200 Mcf AF 1275 psi/72 hrs. development County Line field	2800 Mcf AF 1340 psi/48 hrs. development West Spring Creek pool Spring Creek field	985 Mcf AF 1225 psi/72 hrs. development Dewey Corner's Columbus field	1000 Mcf AF 1325 psi/48 hrs. development Whites Run Columbus field	2000 Mcf AF 1330 psi/72 hrs. development West Spring Creek pool Spring Creek field	1100 Mcf AF 1300 psi/48 hrs. development Whites Run Columbus field

SUMMARIZED RECORDS OF DEEP WELLS

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COUNTY PERMIT NUMBER	Warren 123-40584	Warren 123-40586	Warren 123-40592	Warren 123-40649	Warren 123-40650	Warren 123-40663	Warren 123-40664	Warren 123-40689	Warren 123-40698	Warren 123-40712	
NAME OF WELL	Doutt #1	Brown Unit #1	Hollabaugh-Smith #1	Muzzy #2	Muzzy #1	Smith Unit #1	Luvison #1	Olson/Pierce #1	Clayton Unit #1	Brown Unit #2	
OPERATOR	Douglas Oil & Gas, Inc.	Douglas Oil & Gas, Inc.	M.A.T. Oil & Gas Exploration	Douglas Oil & Gas, Inc.	Douglas Oil & Gas, Inc.	Douglas Oil & Gas, Inc.	Douglas Oil & Gas, Inc.	Douglas Oil & Gas, Inc.	Douglas Oil & Gas, Inc.	Douglas Oil & Gas, Inc.	
TOWNSHIP	Columbus	Pittsfield	Eldred	Eldred	Eldred	Spring Creek	Pittsfield	Spring Creek	Spring Creek	Spring Creek	
QUADRANGLE	Columbus	Lottsville	Grand Valley	Spring Creek	Spring Creek	Spring Creek	Lottsville	Lottsville	Spring Creek	Spring Creek	
LATITUDE	200 ft. S 41°55'00"	8,050 ft. S 41°55'00"	9,300 ft. S 41°45'00"	1,475 ft. S 41°47'30"	600 ft. S 41°47'30"	13,600 ft. S 41°52'30"	9,100 ft. S 41°55'00"	6,600 ft. S 41°55'00"	5,600 ft. S 41°50'00"	5,075 ft. S 41°55'00"	
LONGITUDE	8,150 ft. W 79°30'00"	1,775 ft. W 79°27'30"	12,350 ft. W 79°30'00"	5,200 ft. W 79°32'30"	6,350 ft. W 79°32'30"	3,200 ft. W 79°35'00"	12,050 ft. W 79°25'00"	4,325 ft. W 79°27'30"	7,600 ft. W 79°35'00"	5,050 ft. W 79°27'30"	
DATE COMPLETED	8-14-89	3-3-89	6-19-89	9-22-89	10-6-89	9-26-89	9-6-89	8-29-89	10-28-89	9-15-89	
ELEVATION	1770 GR	1765 GR	1360 GR	1635 GR	1600 GR	1690 GR	1570 GR	1780 GR	1560 GR	1875 GR	
LOGS RECEIVED AND LOGGED INTERVALS	CDL/CNL: 3150-4894	CDL/CNL: 3248-5073		CDL/DLL: 524-5264 PCL: 3300-5262	CDL/DLL: 558-5219 PCL: 3400-5206	CDL/DLL: 3299-5088 PCL: 3400-5035	CDL/DLL: 3150-4879	PCL: 3350-5068	CDL/DLL: 513-5026 PCL: 3100-5005	CDL/DLL: 3400-5174 PCL: 3150-5110	
TULLY LIMESTONE	3203-	3364-	3450-	3474-	3426-	3364-	3186-		3260-	3438-	
ONONDAGA LIMESTONE											
HUNTERSVILLE CHERT	3492-	3640-	3728-	3742-	3696-	3620-	3460-	3618-	3514-	3716-	
ORISKANY SANDSTONE											
RIDGELEY SANDSTONE											
SILURIAN-DEVONIAN CARBONATES	3650-	3794-	3850-	3884-	3846-	3768-	3610-	3771-	3660-	3868-	
SALINA GROUP	3722- 4300-	3856- 4452-	3964- 4576-	3948- 4592-	3918- 4542-	3824- 4446-	3676- 4270-	3832- 4446-	3726- 4366-	3932- 4528-	
LOCKPORT DOLOMITE											
ROCHESTER SHALE	4594- 4636-	4735- 4790-	4876- 4943-	4871- 4933-	4823- 4884-	4738- 4786-	4570- 4610-	4718- 4770-	4652- 4704-	4818- 4864-	
HONDEQUOIT DOLOMITE											
GRIMSBY FORMATION	4674- 4810- 4842-	4828- 4969- 5002-	4986- 5125- 5162-	4976- 5125- 5146-	4930- 5064- 5096-	4824- 5110- 4994-	4651- 4795- 4822-	4810- 4951- 4993-	4755- 4887- 4911-	4904- 5028- 5076-	
WHIRLPOOL SANDSTONE											
QUEENSTON FORMATION	4851-	5014-	5174-	5156-	5106-	5010-	4836-	5002-	4922-	5086-	
PRODUCING FORMATION	Medina	Medina	Medina	Medina	Medina	Medina	Medina	Medina	Medina	Medina	
DEEPEST PRODUCING DEPTH	4792	4918	5170	5152	5012	5000	4768	4918	4827	5080	
TOTAL DEPTH	4960	5100	5319	5297	5236	5105	4980	5127	5044	5245	
DEEPEST FORMATION REACHED	Queenston	Queenston	Queenston	Queenston	Queenston	Queenston	Queenston	Queenston	Queenston	Queenston	
RESULTS	2300 Mcf AF 1300 psi/48 hrs. development Whites Run pool Columbus field	2200 Mcf AF 1320 psi/72 hrs. exploratory (EXT) Whites Run pool Columbus field	1400 Mcf AF 960 psi/48 hrs. development Whites Run pool Spring Creek field	5300 Mcf AF 1425 psi/48 hrs. development Trimm pool Spring Creek field	IP not reported 1300 psi/48 hrs. development Trimm pool Spring Creek field	2100 Mcf AF 1230 psi/48 hrs. development West Spring Creek pool Spring Creek field	3700 Mcf AF 1275 psi/48 hrs. development Whites Run pool Spring Creek field	3700 Mcf AF 1275 psi/48 hrs. development Whites Run pool Spring Creek field	2500 Mcf AF 1240 psi/48 hrs. development Whites Run pool Columbus field	3900 Mcf AF 1350 psi/48 hrs. development West Spring Creek pool Spring Creek field	4700 Mcf AF 1300 psi/48 hrs. development Whites Run pool Columbus field

Figure 47. (Continued).

COUNTY PERMIT NUMBER	Warren 123-40716	Warren 123-40731	Warren 123-40732	Warren 123-40733	Warren 123-40740	Warren 123-40745	Warren 123-40747	Warren 123-40751	Warren 123-40760	Warren 123-40763
NAME OF WELL	Mallery #2	Leofsky, James #1	Sekerak, M. #1	Leofsky, James #2	Mencher, O. #2	Rogers #1	Eastman, H. #1	Trisket, R. #2	Lyons, John #2	Ooutt #2
OPERATOR	Douglas Oil & Gas, Inc.	Cabot Oil & Gas Corp.	Universal Resources Holdings	Cabot Oil & Gas Corp.	Cabot Oil & Gas Corp.	Douglas Oil & Gas, Inc.	Cabot Oil & Gas Corp.	U. S. Energy Exploration Corp.	Cabot Oil & Gas Corp.	Douglas Oil & Gas, Inc.
TOWNSHIP	Pittsfield	Pittsfield	Columbus	Pittsfield	Spring Creek	Columbus	Pittsfield	Columbus	Columbus	Columbus
QUADRANGLE	Pittsfield	Pittsfield	Columbus	Pittsfield	Spring Creek	Columbus	Pittsfield	Columbus	Columbus	Columbus
LATITUDE	3,950 ft. S 4,105'2"30"	10,060 ft. S 4,105'0"00"	4,580 ft. S 4,105'5"00"	10,000 ft. S 4,105'0"00"	2,525 ft. S 4,105'0"00"	2,050 ft. S 4,105'5"00"	5,420 ft. S 4,167'30"	2,160 ft. S 4,200'0"00"	7,050 ft. S 4,155'0"00"	2,400 ft. S 4,105'5"00"
LONGITUDE	12,000 ft. W 79°27'30"	4,400 ft. W 79°27'30"	1,020 ft. W 79°30'00"	6,230 ft. W 79°27'30"	3,080 ft. W 79°30'00"	3,225 ft. W 79°32'30"	7,640 ft. W 79°25'00"	1,600 ft. W 79°32'30"	5,700 ft. W 79°30'00"	8,900 ft. W 79°30'00"
DATE COMPLETED	10-1-89	10-31-89	12-6-89	10-3-89	10-11-89	10-10-89	10-17-89	1-5-90	12-5-89	11-4-89
ELEVATION	1670 GR	1770 GR	1616 GR	1785 GR	1705 GR	1520 GR	1801 GR	1508 GR	1690 GR	1730 GR
LOGS RECEIVED AND LOGGED INTERVALS	PCL: 3200-5116	COL/GR: 0-5400 GR/PCL: 5100-5404	PCL: 2800-4751	GR/PCL: 5070-5379	GR/PCL: 4920-5187	PCL: 2450-4666	GR/PCL: 5300-5624	COL/DNL: 0-4419 OLL: 0-4419 INT: 0-4419	GR/PCL: 4610-4950	COL/DLL: 3095-4939
TULLY LIMESTONE	3366-	3634-	3123-	3638-	3550-	2957-	3807-	2687-	3190-	3184-
ONONDAGA LIMESTONE HUNTERSVILLE CHERT	3642-	3912-	3406-	3918-	3827-	3236-	4095-	2962-	3478-	3472-
ORISKANY SANDSTONE RIDGELEY SANDSTONE				4050-	3966-		4221-			
SILURIAN-DEVONIAN CARBONATES	3789-	4044-	3568-	4056-	3982-	3400-	4226-	3150-	3641-	3628-
SALINA GROUP LOCKPORT DOLOMITE	3850- 4473-	4120- 4738-	3634- 4226-	4379- 4680-	4290- 4558-	3474- 4046-	4492- 4898-	3214- 3778-	4005- 4230-	3698- 4296-
ROCHESTER SHALE IRONDEQUOIT DOLOMITE	4773- 4820-	5026- 5086-	4529- 4567-	5050- 5102-	4927- 4976-	4333- 4379-	5285- 5328-	4042- 4101-	4560- 4640-	4552- 4620-
GRIMSBY FORMATION CABOT HEAD SHALE WHIRLPOOL SANDSTONE	4858- 5008- 5030-	5129- 5261- 5301-	4605- 4743- 4774-	5145- 5286- 5320-	5016- 5149- 5187-	4418- 4543- 4586-	5376- 5500- 5546-	4134- 4256- 4300-	4678- 4819- 4850-	4656- 4780- 4828-
QUEENSTON FORMATION	5039-	5307-	4784-	5326-	5194-	4600-	5554-	4311-	4859-	4838-
PRODUCING FORMATION	Medina	Medina	Medina	Medina	Medina	Medina	Medina	Medina	Medina	Medina
DEEPEST PRODUCING DEPTH	4951	5215	4783	5245	5114	4596	5465	4307	4766	4750
TOTAL DEPTH	5167	5460	4895	5488	5367	4724	5711	4429	4990	4956
DEEPEST FORMATION REACHED	Queenston	Queenston	Queenston	Queenston	Queenston	Queenston	Queenston	Queenston	Queenston	Queenston
RESULTS	4700 Mcf AF 1300 psi/48 hrs. exploratory (EXT) Horn Sliding pool Columbus field	236 Mcf AF 1320 psi/48 hrs. development Trim pool Sanford field	4400 Mcf AF 1300 psi/48 hrs. development Whites Run pool Columbus field	200 Mcf AF 1350 psi/48 hrs. exploratory (EXT) Trim pool Sanford field	166 Mcf AF 1000 psi/48 hrs. development Trim pool Sanford field	6000 Mcf AF 1375 psi/48 hrs. development Whites Run pool Columbus field	348 Mcf AF 1170 psi/48 hrs. exploratory (EXT) Trim pool Sanford field	1300 Mcf AF 1050 psi/72 hrs. development Dewey Corner's pool Columbus field	309 Mcf AF 1240 psi/48 hrs. development Whites Run pool Columbus field	1900 Mcf AF 1250 psi/48 hrs. development Whites Run pool Columbus field

COUNTY PERMIT NUMBER	Warren 123-40764	Warren 123-40783	Warren 123-40795	Warren 123-40796	Warren 123-40797	Warren 123-40798	Warren 123-40799	Warren 123-40801	Warren 123-40802	Warren 123-40803
NAME OF WELL	Vanderhoof, R. #1	Tidioute Water #1-A	Bazant, Henry #4	Tidioute Water #4	Rensma, Morris #1	Upton, R. & G. #2	Burek Unit #1	Doult Unit #2	Black Unit #1	Upton, R. & G. #1
OPERATOR	Cabot Oil & Gas Corp.	Cabot Oil & Gas Corp.	Cabot Oil & Gas Corp.	Cabot Oil & Gas Corp.	Quaker State Corporation	Cabot Oil & Gas Corp.	Douglas Oil & Gas, Inc.	Douglas Oil & Gas, Inc.	Douglas Oil & Gas, Inc.	Cabot Oil & Gas Corp.
TOWNSHIP	Spring Creek	Deerfield	Spring Creek	Deerfield	Spring Creek	Pittsfield	Columbus	Columbus	Columbus	Pittsfield
QUADRANGLE	Spring Creek	Pittsfield	Spring Creek	Pittsfield	Spring Creek	Pittsfield	Columbus	Columbus	Columbus	Pittsfield
LATITUDE	8 720 ft. S 41°50'00"	11 770 ft. S 41°47'30"	5 750 ft. S 41°50'00"	9 195 ft. S 41°47'30"	4 900 ft. S 41°50'00"	10 430 ft. S 41°50'00"	3 800 ft. S 41°55'00"	2 450 ft. S 41°55'00"	5 300 ft. S 41°55'00"	11 400 ft. S 41°50'00"
LONGITUDE	9 080 ft. W 79°30'00"	11 090 ft. W 79°22'30"	1 500 ft. W 79°30'00"	11 100 ft. W 79°22'30"	8 200 ft. W 79°30'00"	9 050 ft. W 79°27'30"	2 800 ft. W 79°32'30"	1 350 ft. W 79°32'30"	2 525 ft. W 79°32'30"	7 720 ft. W 79°27'30"
DATE COMPLETED	12-12-89	11-16-89	1-9-90	12-9-89	10-9-90	2-12-90	1-22-90	1-29-90	2-28-90	1-23-90
ELEVATION	1732 GR	1637 GR	1752 GR	1677 GR	1640 GR	1690 GR	1510 GR	1655 GR	1470 GR	1752 GR
LOGS RECEIVED AND LOGGED INTERVALS	GR/COL: 722-5315	GR/CBL: 4499-5530	GR/PCL: 4950-5259					COL/DLL: 3079-4862 PCL: 2750-4803	COL/DLL: 514-4687 PCL: 4300-4647	GR/PCL: 5100-5412
TULLY LIMESTONE	3530-	3755-	3553-	3752-	3409-	3543-	2969-	3106-	2934-	3611-
ONONDAGA LIMESTONE HUNTERSVILLE CHERT	3796-	4053-	3829-	4047-	3679-	3826-	3246-	3386-	3210-	3890-
ORISKANY SANDSTONE RIDGELEY SANDSTONE		4161-	3962-	4154-						4025-
SILURIAN-DEVONIAN CARBONATES	3936-	4172-	3967-	4168-	3817-	3957-	3410-	3546-	3374-	4032-
SALINA GROUP LOCKPORT DOLOMITE	3994- 4636-	4454- 4880-	4284- 4644-	4444- 4826-	3924- 4504-	4283- 4591-	3482- 4058-	3616- 4207-	3446- 4030-	4350- 4656-
ROCHESTER SHALE IRONDEQUOIT DOLOMITE	4022- 4978-	5178- 5246-	4034- 4988-	5188- 5255-	4753- 4850-	4959- 5034-	4330- 4386-	4462- 4562-	4294- 4362-	5032- 5082-
GRIMSBY FORMATION CABOT HEAD SHALE WHIRLPOOL SANDSTONE	5024- 5160- 5188-	5320- 5438- 5460-	5032- 5154- 5203-	5304- 5448- 5467-	4891- 5019- 5062-	5052- 5199- 5227-	4423- 4554- 4591-	4563- 4686- 4733-	4398- 4535- 4570-	5126- 5270- 5298-
QUEENSTON FORMATION	5198-	5470-	5213-	5479-	5068-	5233-	4607-	4745-	4583-	5328-
PRODUCING FORMATION	Medina	Medina	Medina	Medina	Medina	Medina	Medina	Medina	Medina	Medina
DEEPEST PRODUCING DEPTH	5090	5372	5119	5479	5066	5138	4600	4740	4574	5258
TOTAL DEPTH	5331	5590	5369	5592	5189	5345	4727	4881	5015	5413
DEEPEST FORMATION REACHED	Queenston	Queenston	Queenston	Queenston	Queenston	Queenston	Queenston	Queenston	Queenston	Queenston
RESULTS	IP not reported 1300 psi/48 hrs. development pool Sanford field	IP not reported 1225 psi/48 hrs. exploratory (EXT) Pittsfield pool Day Hill field	478 Mcf AF 1000 psi/48 hrs. development Trim Sanford field	IP not reported 1300 psi/48 hrs. development Pittsfield pool Day Hill field	IP not reported 775 psi/48 hrs. development Trim Sanford field	309 Mcf AF 1180 psi/48 hrs. development pool Sanford field	3500 Mcf AF 1240 psi/72 hrs. development Whites Run pool Columbus field	1400 Mcf AF 1360 psi/72 hrs. development Whites Run pool Columbus field	942 Mcf AF 1260 psi/72 hrs. development Whites Run pool Columbus field	243 Mcf AF 930 psi/48 hrs. development Trim Sanford field

Figure 47. (Continued).

COUNTY PERMIT NUMBER	Warren 123-40806	Warren 123-40815	Warren 123-40822	Warren 123-40823	Warren 123-40826	Warren 123-40837	Warren 123-40838	Warren 123-40839	Warren 123-40841	Warren 123-40844
NAME OF WELL	McChesney, W. #3	Fuller, Ann #1	McChesney, M. #1	Huff, Herbert #1	Moravek, J. #1	Danielson, M. #3	Alsdorf Unit #4	Swanson Unit #1	Holcomb-Murin #1	Emiel, Joseph #1
OPERATOR	Cabot Oil & Gas Corp.	Cabot Oil & Gas Corp.	Douglas Oil & Gas, Inc.	Douglas Oil & Gas, Inc.	Cabot Oil & Gas Corp.	Cabot Oil & Gas Corp.	Douglas Oil & Gas, Inc.	Douglas Oil & Gas, Inc.	Douglas Oil & Gas, Inc.	Douglas Oil & Gas, Inc.
TOWNSHIP	Spring Creek	Columbus	Columbus	Columbus	Spring Creek	Spring Creek	Spring Creek	Spring Creek	Eldred	Columbus
QUADRANGLE	Spring Creek	Columbus	Columbus	Columbus	Spring Creek	Spring Creek	Spring Creek	Spring Creek	Grand Valley	Lottsville
LATITUDE	11,270 ft. S 4,1952'30"	6,640 ft. S 4,1955'00"	1,750 ft. S 4,1955'00"	5,725 ft. S 4,1955'00"	2,275 ft. S 4,1950'00"	3,030 ft. S 4,1947'30"	7,600 ft. S 4,1952'30"	3,025 ft. S 4,1952'30"	5,875 ft. S 4,1945'00"	1,200 ft. S 4,1955'00"
LONGITUDE	2,080 ft. W 7,9930'00"	9,300 ft. W 7,9930'00"	5,650 ft. W 7,9930'00"	1,150 ft. W 7,9932'30"	10,775 ft. W 7,9930'00"	10,050 ft. W 7,9930'00"	5,250 ft. W 7,9932'30"	10,880 ft. W 7,9930'00"	6,750 ft. W 7,9930'00"	11,100 ft. W 7,9937'30"
DATE COMPLETED	6-1-90	1-16-90	1-18-90	4-23-90	1-18-90	5-15-90	10-5-90	2-19-90	2-8-90	3-15-90
ELEVATION	1880 GR	1571 GR	1790 GR	1525 GR	1696 GR	1770 GR	1414 GR	1485 GR	1390 GR	1710 GR
LOGS RECEIVED AND LOGGED INTERVALS		GR/PCL: 4480-4801	CDL/DLL: 3225-4998 PCL: 2900-4926	CDL/DLL: 514-4756 PCL: 2600-4709	GR/PCL: 4800-5118			CDL/LL: 3000-4844 PCL: 2850-4808	CDL/DLL: 800-5335 PCL: 3400-5301	CDL/DLL: 515-4968 PCL: 2800-4856
TULLY LIMESTONE	3586-	3050-	3242-	3004-	3443-	3650-	3076-	3042-	3492-	3204-
ONONDAGA LIMESTONE HUNTERSVILLE CHERT	3870-	3338-	3532-	3084-	3710-3850-	3921-	3344-	3320-	3782-	3486-
ORISKANY SANDSTONE RIDGELEY SANDSTONE	4020-	3497-				4055-				
SILURIAN-DEVONIAN CARBONATES	4040-	3501-	3688-	3444-	3856-	4060-	3498-	3481-	3912-	3642-
SALINA GROUP LOCKPORT DOLOMITE	4342-4619-	3864-4092-	3758-4342-	3516-4100-	4190-4440-	4382-4762-	3564-4176-	3557-4162-	3984-4622-	3710-4292-
ROCHESTER SHALE IRONDEQUOIT DOLOMITE	5015-5084-	4451-4492-	4612-4678-	4366-4430-	4791-4856-	5051-5134-	4462-4513-	4432-4500-	4902-4986-	4544-4628-
GRIMSBY FORMATION CABOT HEAD SHALE WHIRLPOOL SANDSTONE	5086-5235-5253-	4530-4663-4705-	4710-4884-	4466-4604-4640-	4900-5033-5064-	5155-5301-5326-	4557-4672-4722-	4544-4708-	5011-5152-5186-	4662-4800-4833-
QUEENSTON FORMATION	5264-	4716-	4898-	4654-	5076-	5336-	4734-	4720-	5196-	4843-
PRODUCING FORMATION	Medina	Medina	Medina	Medina	Medina	Medina	Medina	Medina	Medina	Medina
DEEPEST PRODUCING DEPTH	5262	4626	4807	4645	5012	5335	4726	4712	5111	4765
TOTAL DEPTH	5382	4865	5015	4772	5185	5440	4918	4849	5335	4988
DEEPEST FORMATION REACHED	Queenston	Queenston	Queenston	Queenston	Queenston	Queenston	Queenston	Queenston	Queenston	Queenston
RESULTS	228 Mcf AF 1160 psi/48 hrs. development Horn Siding pool Columbus field	378 Mcf AF 1225 psi/48 hrs. development Whites Run pool Columbus field	1000 Mcf AF 1150 psi/72 hrs. development Whites Run pool Columbus field	2600 Mcf AF 1350 psi/72 hrs. development Whites Run pool Columbus field	214 Mcf AF 1320 psi/48 hrs. development Trim sanford field	253 Mcf AF 1220 psi/48 hrs. development Trim sanford field	IP not reported 1250 psi/72 hrs. development West Spring Creek pool Spring Creek field	869 Mcf AF 1350 psi/72 hrs. development Horn Siding pool Columbus field	1000 Mcf AF 1270 psi/72 hrs. development Campbell Creek pool Goodwill Hill- Grand Valley field	1700 Mcf AF 1125 psi/72 hrs. development Whites Run pool Columbus field

COUNTY PERMIT NUMBER	Warren 123-40845	Warren 123-40862	Warren 123-40867	Warren 123-40868	Warren 123-40871	Warren 123-40878	Warren 123-40888	Warren 123-40889	Warren 123-40915	Warren 123-40928
NAME OF WELL	Crocker Unit #1	Emiel Unit #1	Lyons, William #2	Simitoski, G. #1	Doutt, David #1	Upton Lumber Unit #1	Emiel #2	Wood Farm #1	Day #1	Burleigh, E. #1
OPERATOR	Quaker State Corporation	Douglas Oil & Gas, Inc.	Douglas Oil & Gas, Inc.	Douglas Oil & Gas, Inc.	Douglas Oil & Gas, Inc.	Douglas Oil & Gas, Inc.	Douglas Oil & Gas, Inc.	Quaker State Corporation	Quaker State Corporation	Quaker State Corporation
TOWNSHIP	Southwest	Columbus	Spring Creek	Spring Creek	Columbus	Pittsfield	Columbus	Eldred	Eldred	Eldred
QUADRANGLE	Tidioute	Columbus	Lottsville	Lottsville	Columbus	Pittsfield	Columbus	Grand Valley	Grand Valley	Grand Valley
LATITUDE	3,675 ft. S 4,1042'30"	13,175 ft. S 4,1057'30"	7,575 ft. S 4,1055'00"	5,775 ft. S 4,1055'00"	3,100 ft. S 4,1055'00"	6,800 ft. S 4,1050'00"	14,850 ft. S 4,1057'30"	1,000 ft. S 4,1042'30"	13,500 ft. S 4,1045'00"	14,500 ft. S 4,1045'00"
LONGITUDE	10,610 ft. W 7,9027'30"	825 ft. W 7,9030'00"	7,900 ft. W 7,9027'30"	6,450 ft. W 7,9027'30"	11,300 ft. W 7,9030'00"	7,525 ft. W 7,9027'30"	450 ft. W 7,9030'00"	11,100 ft. W 7,9030'00"	3,000 ft. W 7,9030'00"	7,720 ft. W 7,9030'00"
DATE COMPLETED	3-1-90	3-27-90	5-14-90	5-2-90	5-22-90	3-28-90	3-20-90	3-16-90	9-18-90	11-13-90
ELEVATION	1720 GR	1670 GR	1800 GR	1870 GR	1700 GR	1425 GR	1650 GR	1480 GR	1740 GR	1720 GR
LOGS RECEIVED AND LOGGED INTERVALS		CDL/DLL: 519-4871 PCL: 2850-4860	CDL/DLL: 3300-5142 PCL: 4700-5120	GR/CDL: 3400-5214 PCL: 3200-5184	CDL/DLL: 3100-4925 PCL: 3000-4882	CDL/DLL: 515-5046	GR/CDL: 3100-4899 PCL: 2900-4867			
TULLY LIMESTONE	3980-	3140-	3356-	3424-	3146-	3253-	3144-	3644-	3931-	3899-
ONONDAGA LIMESTONE	4265-	3426-	3636-	3706-	3630-	3530-	3430-	3916-	4220-	4187-
HUNTERSVILLE CHERT										
ORISKANY SANDSTONE	4363-									
PIGEEY SANDSTONE										
SILURIAN-DEVONIAN CARBONATES	4385-	3588-	3796-	3864-	3590-	3664-	3588-	4044-	4342-	4306-
SALINA GROUP	4517-	3660-	3862-	3928-	3661-	3724-	3654-	4159-	4456-	4428-
LOCKPORT DOLOMITE	5125-	4222-	4466-	4528-	4242-	4360-	4230-	4767-	5049-	5015-
ROCHESTER SHALE	5376-	4475-	4734-	4773-	4510-	4648-	4482-	5013-	5295-	5263-
IRONDEQUOIT DOLOMITE	5483-	4558-	4802-	4864-	4575-	4702-	4567-	5119-	5400-	5368-
GRIMSBY FORMATION	5530-	4502-	4836-	4904-	4612-	4743-	4603-	5164-	5447-	5414-
CAROT HEAD SHALE	5671-	4736-	4965-	5050-	4730-	4882-	4730-	5284-	5384-	5384-
WHIRLPOOL SANDSTONE	5703-	4768-	5012-	5076-	4785-	4920-	4781-	5339-	5619-	5589-
QUEENSTON FORMATION	5718-	4778-	5030-	5087-	4798-	4924-	4790-	5351-	5632-	5601-
PRODUCING FORMATION	Medina	Medina	Medina	Medina	Medina	Medina	Medina	Medina	Medina	Medina
DEEPEST PRODUCING DEPTH	5713	4771	5019	5081	4790	4857	4784	5348	5625	5595
TOTAL DEPTH	5835	4898	5152	5223	4935	5070	4908	5471	5767	5718
DEEPEST FORMATION REACHED	Queenston	Queenston	Queenston	Queenston	Queenston	Queenston	Queenston	Queenston	Queenston	Queenston
RESULTS	1400 Mcf AF 1050 psi/48 hrs. development Campbell Creek pool Goodwill Hill- Grand Valley field	1100 Mcf AF 1240 psi/72 hrs. development Whites Run pool Columbus field	1500 Mcf AF 900 psi/72 hrs. development Whites Run pool Columbus field	1900 Mcf AF 1240 psi/72 hrs. development Whites Run pool Columbus field	IP not reported 1180 psi/72 hrs. development Whites Run pool Columbus field	IP not reported 1360 psi/72 hrs. development Trim Sanford field	IP not reported 1265 psi/48 hrs. development Whites Run pool Church Run field	1700 Mcf AF 1265 psi/48 hrs. development Whites Run pool Church Run field	IP not reported 1160 psi/48 hrs. development Campbell Creek pool Goodwill Hill- Grand Valley field	IP not reported 1365 psi/48 hrs. development Campbell Creek pool Goodwill Hill- Grand Valley field

Figure 47. (Continued).

COUNTY PERMIT NUMBER	Warren 123-40932	Warren 123-40934	Warren 123-40942	Warren 123-40949	Warren 123-40959	Warren 123-40979	Warren 123-40994	Warren 123-40998	Warren 123-41003	Warren 123-41006
NAME OF WELL	Caldwell, C. #3	Schwab, Fisher #4	Byles #3	Getz, Rensma #2	Leech Unit #1	Byles #4	Morando, R. #1	Wakeman #1	Zane #1	Hunter #1
OPERATOR	Quaker State Corporation	Quaker State Corporation	Quaker State Corporation	Quaker State Corporation	Quaker State Corporation	Quaker State Corporation	Kidder Exploration, Inc.	Quaker State Corporation	Quaker State Corporation	Quaker State Corporation
TOWNSHIP	Eldred	Southwest	Southwest	Southwest	Eldred	Southwest	Sugar Grove	Southwest	Southwest	Southwest
QUADRANGLE	Grand Valley	Grand Valley	Grand Valley	Grand Valley	Grand Valley	Grand Valley	Sugar Grove	Grand Valley	Grand Valley	Grand Valley
LATITUDE	9,050 ft. S 41°45'00"	1,950 ft. S 41°40'00"	6,280 ft. S 41°42'30"	14,304 ft. S 41°42'30"	10,350 ft. S 41°45'00"	4,580 ft. S 41°42'30"	4,000 ft. S 42°00'00"	9,550 ft. S 41°42'30"	4,500 ft. S 41°42'30"	8,000 ft. S 41°42'30"
LONGITUDE	8,000 ft. W 79°32'30"	7,350 ft. W 79°30'00"	9,850 ft. W 79°32'30"	5,427 ft. W 79°35'00"	8,980 ft. W 79°32'30"	9,250 ft. W 79°32'30"	7,900 ft. W 79°20'00"	1,075 ft. W 79°32'30"	10,325 ft. W 79°30'00"	1,850 ft. W 79°32'30"
DATE COMPLETED	11-1-90	11-6-90	10-17-90	10-2-90	10-22-90	10-30-90	9-18-90	9-27-90	9-24-90	10-10-90
ELEVATION	1620 GR	1485 GR	1320 GR	1300 GR	1605 GR	1340 GR	1700 GR	1665 GR	1535 GR	1560 GR
LOGS RECEIVED AND LOGGED INTERVALS							COL/CNL: 0-4802 GR/OLL: 0-4802 GR/T: 0-4802 INT: 0-4802			
TULLY LIMESTONE	3665-	3818-	3488-	3483-	3681-	3504-	3064-	3894-	3767-	3762-
ONONDAGA LIMESTONE HUNTERSVILLE CHERT	3935-	4107-	3764-	3760-	3955-	3783-	3354-	4177-	4050-	4044-
ORISKANY SANDSTONE RIDGELEY SANDSTONE		4212-	3877-	3883-		3910-		4284-	4154-	
SILURIAN-DEVONIAN CARBONATES	4067-	4237-	3896-	3910-	4100-	3917-	3518-	4310-	4173-	4151-
SALINA GROUP LOCKPORT DOLOMITE	4176- 4785-	4377- 5000-	4030- 4638-	4028- 4652-	4198- 4787-	4034- 4843-	3573- 4148-	4433- 5024-	4300- 4890-	4298- 4891-
ROCHESTER SHALE IRONDEQUOIT DOLOMITE	5039- 5146-	5234- 5343-	4894- 4994-	4946- 5021-	5066- 5170-	4908- 5005-	4404- 4488-	5299- 5409-	5155- 5262-	5166- 5278-
GRIMSBY FORMATION CAROT HEAD SHALE WHIRLPOOL SANDSTONE	5193- 5318- 5365-	5392- 5548- 5568-	5039- 5165- 5208-	5079- 5209- 5242-	5217- 5329- 5385-	5051- 5172- 5227-	4526- 4637- 4687-	5457- 5599- 5630-	5307- 5446- 5484-	5325- 5464- 5500-
QUEENSTON FORMATION	5376-	5580-	5221-	5252-	5396-	5237-	4700-	5644-	5494-	5512-
PRODUCING FORMATION	Medina	Medina	Medina	Medina	Medina	Medina	Medina	Medina	Medina	Medina
DEEPEST PRODUCING DEPTH	5316	5546	5216	5249	5393	5203	4696	5604	5444	5505
TOTAL DEPTH	5408	5680	5336	5385	5525	5353	4812	5780	5636	5657
DEEPEST FORMATION REACHED	Queenston	Queenston	Queenston	Queenston	Queenston	Queenston	Queenston	Queenston	Queenston	Queenston
RESULTS	IP not reported 1350 psi/48 hrs. development Campbell Creek pool Goodwill Hill- Grand Valley field	IP not reported 1200 psi/48 hrs. development Seldom Seen pool Colorado field	IP not reported 1120 psi/48 hrs. development Campbell Creek pool Goodwill Hill- Grand Valley field	IP not reported 1050 psi/48 hrs. development Porky Run pool ootyville field	IP not reported 1165 psi/48 hrs. development Campbell Creek pool Goodwill Hill- Grand Valley field	IP not reported 1190 psi/48 hrs. development Campbell Creek pool Goodwill Hill- Grand Valley field	IP not reported 620 psi/48 hrs. development Campbell Creek pool Goodwill Hill- Grand Valley field	350 Mcf AF 1020 psi/96 hrs. development Stillwater field	IP not reported 1020 psi/48 hrs. development Campbell Creek pool Goodwill Hill- Grand Valley field	IP not reported 1050 psi/48 hrs. development Campbell Creek pool Goodwill Hill- Grand Valley field

COUNTY PERMIT NUMBER	County	Permit Number	Well Name	Operator	Township	Quadrangle	Latitude	Longitude	Date Completed	Elevation	Logs Received and Logged Intervals	Geology	Remarks
	Warren	123-41030	Peterson, H. #3	Quaker State Corporation	Southwest	Grand Valley	675 ft. S 41°40'00"	925 ft. W 79°30'00"	11-16-90	1470 GR		TULLY LIMESTONE	
												ONONDAGA LIMESTONE HUNTERSVILLE CHERT	
												ORISKANY SANDSTONE RIDGELEY SANDSTONE	
												SILURIAN-DEVONIAN CARBONATES	
												SALINA GROUP LOCKPORT DOLOMITE	
												ROCHESTER SHALE IRONDEQUOIT DOLOMITE	
												GRIMSBY FORMATION CAROT HEAD SHALE WHIRLPOOL SANDSTONE	
												QUEENSTON FORMATION	
												PRODUCING FORMATION	
												DEEPEST PRODUCING DEPTH	
												TOTAL DEPTH	
												DEEPEST FORMATION REACHED	
RESULTS												IP not reported 1230 psi/48 hrs. development Campbell Creek pool Goodwill Hill- Grand Valley field	

